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Report

North Carolina Agricultural Experiment Station

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TWENTY-EIGHTH ANNUAL REPORT

OF THE

NORTH CAROLINA

Agricultural Experiment Station

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

FOR THE

YEAR ENDING JUNE 30, 1905.

INCLUDING

BULLETINS NOS. 190, 191, 192.

RALEIGH, NORTH CAROLINA.

RALEIGH:
PRESSES OF EDWARDS & BROUGHTON.
1906.

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Sci 1636.15
From the
Quarterly Journal
of Economics.
N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.
AUG 10 1905
BOUND JUN 22 1915

THE NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

S. L. PATTERSON, *ex officio* Chairman, Raleigh.

J. M. FOREHAND ..... Tyner.	A. T. MCCALLUM ..... Red Springs.
J. B. STOKES ..... Windsor.	J. P. MCRAE ..... Laurinburg.
WM. DUNN ..... Newbern.	R. L. DOUGHTON ..... Laurel Springs.
C. N. ALLEN ..... Auburn.	S. T. WILFONG ..... Newton.
R. W. SCOTT ..... Melville.	A. CANNON ..... Horse Shoe.

STATION STAFF.

GEORGE T. WINSTON, L.L D., President of the College.

B. W. KILGORE ..... Director.
W. A. WITHERS ..... Chemist.
W. F. MASSEY ..... Horticulturist.
C. W. BURKETT ..... Agriculturist.
TAIT BUTLER ..... Veterinarian.
F. L. STEVENS ..... Biologist.
FRANKLIN SHERMAN, JR ..... Entomologist.
CHARLES WALKER ..... Assistant Chemist.
J. S. JEFFREY ..... Poultryman.
B. F. WALTON ..... Assistant in Field Experiments.
J. C. KENDALL ..... Assistant Dairy Husbandry.
A. F. BOWEN ..... Bursar.

The Director's office is in the Agricultural Building, Raleigh: the experiment grounds and laboratories being at the Agricultural College, just west of town and on the street car line.

Visitors will be welcome at all times, and will be given every opportunity to inspect the work of the Station. Bulletins and Reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

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Bulletins—

No. 190, The Formation of Nitrates in the Soil.

No. 191, Egg Preservation.

No. 192, Farm Dairying.

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LETTER OF TRANSMITTAL.

RALEIGH, N. C., June 30, 1905.

To His Excellency, ROBERT B. GLENN,
Governor of North Carolina.

SIR:—I have the honor to transmit herewith the report of the operations of the Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts, for the year beginning July 1, 1904, and ending June 30, 1905.

Very respectfully,

S. L. PATTERSON,
Chairman Board of Trustees.

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LETTER OF SUBMITTAL.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,
OFFICE OF THE DIRECTOR,

RALEIGH, N. C., June 30, 1905.

HON. S. L. PATTERSON, *Chairman Board of Trustees.*

SIR:—I have the honor to submit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts, for the year ending June 30, 1905.

Trusting that this report will prove satisfactory, I am,

Very respectfully,

B. W. KILGORE,
Director.

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TWENTY-EIGHTH ANNUAL REPORT

OF THE DIRECTOR OF THE

N. C. AGRICULTURAL EXPERIMENT STATION.

For the Year Ending June 30th, 1905.

By the Director.

The present report covers the operations of the Station from July 1, 1904, to June 30, 1905.

CHANGES IN STATION STAFF.

Mr. W. G. Morrison, assistant chemist, resigned to accept another position, and Dr. Charles Walker was appointed to succeed him.

WORK IN THE AGRICULTURAL DIVISION.

With cotton and corn, fertilizer, culture, and variety tests have been continued, as described in detail in the report for 1902, with a view of collecting further data on these subjects. Publication of the results will be made when it is felt that sufficient data has been collected.

Tests have been made of a considerable number of grasses and legumes and mixtures of these for pasture and for hay, and the question of alfalfa production is receiving careful study. Experiments with cow peas, soja beans and wheat have been continued, as have also the feeding experiments with horses and mules, and work with dairy cattle.

WORK IN THE CHEMICAL DIVISION.

As in the past few years, work in the Chemical Division has been devoted to a study of nitrogeneous fertilizer materials and their conversion into plant food through the agency of the bacteria in the soil, together with the effectiveness of the bacteria in the different soils for bringing this about. Attention has also been given to the food requirements of bacteria to aid them in doing most effective work. Along with this it has been necessary to develop methods for the various determinations, and progress has been made in this line.

WORK IN THE HORTICULTURAL DIVISION.

The production of flowering bulbs has received attention at the hands of the Horticulturist, who considers that results obtained in

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the eastern part of the State justify the expectation that large quantities of various flowering bulbs can be successfully grown at such cost as to make it a profitable commercial enterprise.

The experiments in the determination of one or more varieties of sweet corn suitable to our Southern conditions have been continued, as have also the tests with a large number of grapes, apples, peaches, pears, plums and garden vegetables.

A large correspondence has been conducted and considerable Farmers' Institute work done by the Horticulturist.

WORK IN THE BIOLOGICAL DIVISION.

The Biologist presents in considerable detail the work which has been done by him during the year in connection with the study of plant diseases and methods for combatting them. Asparagus rust and a sweet potato wilt are reported among the new, or comparatively new diseases affecting our farms and truck crops. Plans are being made to study the sweet potato wilt, with a view of finding a variety which will withstand this disease, as has been done with the cow pea and cotton. .

The main work of the year has been with the Granville tobacco wilt along the lines followed during the past two years, and with the watermelon wilt in continuation of the experiments in co-operation with the Bureau of Plant Industry, of the United States Department of Agriculture. A large number of varieties of tobacco were used in the tobacco wilt soil, without finding one that was sufficiently largely resistant to enable it to be grown in a commercial way, though there was a considerable difference in the resistance of different varieties to the disease. Seed were selected from the more resistant sorts for use in further tests this season, in the hope of increasing the power of withstanding the disease. Various chemicals were applied, such as are usually employed for destroying diseases of this kind on the plants without finding anything which was effective.

The watermelon wilt work, while encouraging, is not sufficiently definite as yet in results to justify conclusions. It is an important matter, however, and will be continued in the future.

WORK IN THE VETERINARY DIVISION.

The veterinary work in the State is largely supported by the State Department of Agriculture, though the Station gives such help to this as its funds will justify.

In addition to dealing with the various diseases of domestic animals and giving general encouragement to the live stock interests of the State, the Veterinarian has devoted especial efforts to the development of methods for the extermination of the Southern cattle fever tick. Decided progress has been made in this work, and more than ten counties have already been freed from this pest.

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WORK IN THE POULTRY DIVISION.

The equipment for the poultry plant which has been in gradual progress during the past two and one-half years is about completed, and is now in very good shape for this line of work. The healthfulness and quality of the stock is greatly improved, and we have been able to dispose of all surplus eggs for hatching purposes and stock for breeding which we could spare, the prices received for breeding stock being much in advance of what we had gotten previously because of improvement in the quality of what we had to offer. Experiments have been continued with methods of feeding poultry and preservation of eggs. A Bulletin was issued the past season on egg preservation, and we shall have another one shortly on feeding poultry. Records are kept of the egg production from the different breeds to help determine the merits of the different kinds. Eggs from the largest layers are being kept separate, with a view of further increasing egg production.

Some special work in breeding along this line has been put in operation.

WORK IN THE ENTOMOLOGICAL DIVISION.

The expenses of the entomological work are met by the Department of Agriculture. A large amount of valuable work has been done to aid the farmers of the State. Some experimental work is done in which the Station is paying the actual cost of material and for the extra labor.

PUBLICATIONS.

Bulletins have been issued as follows:

No. 190—The Formation of Nitrates in the Soil, by W. A. Withers.

No. 191—Egg Preservation, by J. S. Jeffrey.

No. 192—Farm Dairying, by J. C. Kendall.

REPORTS OF HEADS OF DIVISIONS AND FINANCIAL STATEMENT.

The reports of the heads of the several divisions of the Station and financial statement follow:

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REPORT OF THE AGRICULTURAL DIVISION.

PROF. B. W. KILGORE, *Director:*

DEAR SIR:—In accordance with your request I herewith submit my report for the year past. In this division the station work has been centered along the same lines as outlined in previous reports. From the nature of these experiments they are planned to extend through a series of years that fundamental information as well as practical help may be obtained.

One hundred and five acres of land are now cleared and included in the work devoted to Experiment Station work. This quantity is sufficient in every sense of the word for the needs of the Division.

AGRONOMY AND PLANT PRODUCTION.

Several hundred plats are used for investigation in agronomy and plant production. These plats, used for this work, are one-tenth, one-twentieth, and one-fortieth of an acre in size. At the present time the following lines of work are being considered.

1. *Grasses and Forage Crops:* A great number of grasses and forage crops have been tested. The majority of these have not proved at home under our conditions. The vetches, clovers, cow peas, soja beans, Newman beans, corn and Bermuda grass have all done splendidly and suggest good possibilities for live stock husbandry. The work along this line has been extended and will also be extended as new questions are suggested by the work now in progress.

2. *Cow peas:* These have been tested in reference to time of planting, quantity of seed, methods of planting, varieties and fertilization. They are also being studied as a part of the work in soil improvement.

3. *Wheat:* The preliminary work in wheat culture has been done where it has been studied in relation to cow peas, in relation to varieties and the time of planting. The areas that have been devoted to wheat culture will now go to soil improvement crops that involve a system of rotation extending through three years, after which wheat will be followed covering the same tests that have been previously made.

4. *Corn:* The experiments with this crop are reasonably extensive in nature, and cover the important factors that have to do with corn culture. The tests include the fertilization of corn, rotation of crops in reference to corn growing, time of planting, varieties and quantity of seed and fertilizers per acre.

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5. *Soja beans:* Experiments with soja and Newman beans include fertilizer tests, varieties, quantity of seed, methods of planting, effect of liming, etc. This is the second year of this work, and it will be continued through two more years, so that it may be as complete as possible to offer suggestions in the use of this crop under our conditions.

6. *Cotton:* Tests along the same line as corn are being conducted with cotton.

7. *Alfalfa:* Work with the alfalfa crop consists of testing of spring and fall seeding, and includes fertilizer values, effect of inoculation, effect of subsoiling, and liming, spring disking, etc. About a dozen new plats have been seeded to alfalfa this fall.

SOIL IMPROVEMENT.

In developing the Station and College farm about one hundred and fifty acres of old, worn-out lands have been taken in, the scrub pines and oaks cut, and the fields plowed and kept under constant rotation. The problem of culture for such lands is receiving a great deal of attention by this Division, and it is expected that the results will prove not only interesting but extremely valuable, as a means of building up and restoring old lands of the State to good producing power.

FEEDING FARM HORSES AND MULES.

Since the preliminary bulletin on the feeding of farm horses and mules the work is being continued and includes numerous comparisons of feeding stuffs, both roughage and concentrates. The work-stock is weighed each week, and daily work recorded.

THE DAIRY INDUSTRY.

The dairy industry of the state is not only developing at the present time but presents tremendous possibilities for future work. When we consider the fact that a good part of the manufactured dairy products used in the State is brought from other States, it suggests the importance of a careful consideration of this industry. Our manufacturing interests are passing through a marvelous development, and these will call for increased supplies of milk and butter and cheese. Hence, this Division is giving careful attention to dairy education, improvement of dairy stock, the production of milk and butter, and the sanitary care of the same. In this investigation the whole college herd is used. At the same time the work includes a study of the cost of producing milk and butter with Southern feeds, and under Southern conditions; the milk and butter capacity of the dairy cows; the per cent of butter fat, of each individual in the herd; methods and practices in farm dairying, etc. For each cow is being

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kept a careful record of milk produced, the per cent of butter fat, and the total yield of butter produced and its value through each lactation period.

CONCLUSION.

I desire to express my high appreciation of the work of Mr. J. C. Kendall, assistant in dairy husbandry, and the work of Mr. B. F. Walton, assistant in agronomy and field work.

Respectfully submitted,

CHARLES WM. BURKETT,
Agriculturist.

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REPORT OF THE CHEMICAL DIVISION.

PROF. B. W. KILGORE, *Director.*

DEAR SIR:—During the past year the principal work of the chemical division has been a continuation of the study of nitrification. Previous work by this division has shown that different nitrogeneous substances are nitrified more or less readily, and that different soils vary in their power to induce nitrification. In our previous work the nitrogeneous substances which were used to the greatest extent were ammonium sulphate and cottonseed meal, and to a smaller extent dried blood, bone, tankage, etc.

This difference in materials and soils in reference to nitrification is due to a difference in the organisms which induce nitrification, a difference in the food and possibly the toxic substances present in the soils, and a difference in the ease with which the nitrogenenous substances are decomposed.

As the organic nitrogenenous materials which have been used contain various amounts of other fertilizing elements than nitrogen which may serve as food for the organisms, the work has been modified during the past year by the substitution of asparagin for these organic materials. In our comparative tests, therefore, this year, the two materials which were mainly used were ammonium sulphate and asparagin, these two being representatives of inorganic and organic nitrogenous compounds.

During the past year we have exposed several samples of garden soil to the air and weather, and from time to time have made tests of the nitrifying power of the soil, with the view to ascertaining the changes which took place in the numbers of organisms in the soil at different periods of the growing season. Near to these samples have been placed samples of the same soil, which were previously sterilized, having in view as the object the testing of the rapidity with which the nitrifying organisms are transferred from one portion of the soil to an adjacent portion.

Some experiments have been begun to ascertain the character of inorganic foods needed for nitrifying bacteria, which are deficient in various soils, or are present in ample quantities. This is shown by the addition of varying substances to the soil, or by the treatment of soils with various solvents. Among the samples which were used are samples of soils which are known to respond favorably in the field to the addition of certain substances, as shown by the increase in plant growth.

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In connection with our work are some modifications of the method for ascertaining the quantity of nitrates formed. Among these modifications are: 1. Continued shaking of the soil for six hours, instead of simply allowing the water to stand in contact with the soil. In this way the nitrates are more completely dissolved. 2. The gas which is evolved by the Tiemann-Shulze method has been supposed to consist entirely of nitric oxide. In our work with soils we have found other gases present which may come from the air which has been dissolved in the solutions used or otherwise. Correction has been made this year for this error, thus enabling us to secure greater accuracy. 3. In each sample the determination of nitrites as well as nitrates has been made this year, although as a rule they have been found to be present in only small quantities.

The division is continuing this work along the lines indicated.

Very respectfully,

W. A. WITHERS,
Chemist.

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REPORT OF THE HORTICULTURAL DIVISION.

PROF. B. W. KILGORE, *Director.*

I submit the following report of the Division of Horticulture for the year ending July 1, 1905:

I have continued, so far as space and facilities would allow, the experiments with flowering bulbs begun a number of years ago at the earnest solicitation of the dealers in these products in New York, who desire to have the bulbs they need grown in this country rather than to import them from abroad. The efforts to produce the Bermuda Lily here have so far not been successful, except to prove that they will increase in numbers wonderfully, but fail to make the size of bulb that the trade needs. We believe that in competent hands in the moister soil of the coast plain these lilies, which are now imported to the extent of over a million dollars annually, can be produced on a commercial scale here. We have demonstrated that even in the dry soil at Raleigh the old white lily, the Candidum, can be grown here in better quality than any bulbs that are imported from Europe. Bulbs of this lily which I sent to New York several years ago, were pronounced the finest ever seen there, and recently a sample sent from Eastern North Carolina to the veteran bulb grower, C. L. Allen, of Floral Park, N. Y., was pronounced by him the finest he had ever seen, and he gave it as his opinion that North Carolina could beat the world growing flowering bulbs. The Gladiolus does remarkably well here, and the Nerine or Guernsey lily, which is a greenhouse bulb in the North, is perfectly hardy and makes finer bulbs than any imported. I have last year furnished the Department of Agriculture with specimens of this bulb and also of the Sternbergia lutea, a yellow fall-blooming Amaryllid. These did finely there, but the result with the Nerines was not satisfactory, and at the request of Mr. Pieters, of the Division of Plant Industry, I have sent him a second lot for further trial. But that these bulbs can be produced in any desired quantity in North Carolina is beyond question. Roman Hyacinths are in great demand by the florists for winter forcing, and with the proper moist soil, such as the eastern growers select for strawberries, and by planting late in the fall I think that they can be produced here of finer quality than those imported from France. If planted too early in the fall these hyacinths grow at once and get into bloom by Christmas, and then have the coldest weather of the winter on their tops. They should not be planted till the middle of November, after the soil has gotten cool, and then the coming

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of cold will keep them back till after the middle of February, after which they will have the proper weather for maturing their growth. The hyacinths known as the White Italian are larger and later than the Romans, and these have done finely here, making bulbs as large as the Dutch hyacinths. They are in some demand for Easter forcing by florists. Owing to the fact that the Bermuda lily has developed a disease in the Bermuda Islands they have not given so much satisfaction of late, and there is a growing demand for the Candidums and at a higher price than the Bermudas, and the North Carolina growers should take advantage of this fact. Our growers are already supplying the Northern and European market with tuberose bulbs, and also with Caladiums and Cannas, so that there is no need for special testing of these except to study any diseases that may appear. Another bulb which has done remarkably well here is Amaryllis Johnsonii. This makes here immense bulbs and is hardy with slight protection of leaves in winter. But for commercial purposes they should be lifted in the fall and stored in a moist pit or cellar where their roots can be kept alive so that they can be forced at any time. These increase rather slowly by offsets, but sell for a higher price than most other bulbs. Bulbs which I have grown and exhibited North were far larger and better than those I have seen imported. I have now growing some seedlings from crosses of different species of Amaryllis which I hope to bloom another year, and am expecting good results from them. I have also grown some seedling Cannas which are very fine and fully equal to any of the named sorts and are of a great range of colors. The best of these I intend to increase and place in commerce. The various species of Narcissus all do well here but will do better in a more moist soil in the east. The Magnolia growers are experimenting with these and will doubtless succeed. It would seem that a fine trade could be made here by growing the Narcissus and Roman hyacinths in cold frames covered with glass sashes and shipping the flowers North in winter and spring, as we can produce them much more cheaply than they can be grown in the Northern hot houses. This matter could well be tested by the Station.

In the vegetable line I have been testing varieties of lettuce in the hope of finding a better variety for our growers than the Big Boston, which is about the only variety grown in Eastern North Carolina. The results of this work prove that for the fall and winter crop in frames there is no better sort to be had than the Big Boston, though there is very little difference in quality between this and the California Cream Butter Lettuce. The varieties tested the past season were the Giant Crystal Heal, Hanson, Maximum, Grand Rapids, the New Unrivalled and the Wonderful or Shellum. For the spring crop, to follow the winter crop of Big Boston the Wonderful or Shel-

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lum lettuce as it is known in Raleigh, is very superior. It makes very large and hard heads, but is of little use for winter heading, but stands longer without running to seed than the Big Boston, and for sowing in late fall and setting in the open ground like early cabbages for heading in spring is by far the best sort that can be used. It is similar to but larger and heavier than Hanson, and being less brittle than that variety can be shipped better.

Variety tests of tomatoes have been continued. The varieties grown were Maule's Enormous, Ponderosa, Matchless, Imperial, Success, Beauty, Magnificent, Acme, Texas Belle, Forhook Fancy and Dwarf Champion. Of the very large sorts Maule's Enormous is far better and smoother than the Ponderosa, but both are too large for general use and are of more value for exhibition than for any other purpose. For general cultivation we have found nothing better than Success of the red sorts and Acme of the pink ones. A new starting point however has been found in the Texas Belle. This is the result of a cross of the small Cherry tomato with a larger one. It is still a small, smooth tomato and enormously productive. But its chief value is in its resistance to Southern blight and rot. I have never had a plant to blight nor a tomato to rot on it though lying on the ground. We have long known that the little cherry and plum-shaped tomatoes were resistant to blight and rot, and we have been trying to get some of this resistant character into a larger tomato. The Texas Belle is an admirable starting point for selection, and we will use it for this purpose. It is now of a nice size for canning whole, and its enormous production will make it valuable for canners. Selecting this into larger form while retaining its resistant character will be a good work for the new test farm in the East, and should result in the production of a tomato that will be of great value to the South. Our seed was contributed by the Austin Nursery Co., Austin, Texas. They place such a high value on it that they ask $1.00 per paper for the seed, but kindly sent me a free package for test. I believe that it will mark a new era in tomatoes for the South.

Several varieties of onions were tested, and we find that the Brown Australian seems well adapted to Southern conditions and makes a very handsome onion. The same result was found, I believe, at the New Mexico station. Being quite hardy it is a good variety to sow in early fall for spring green onions and for ripening, as it seems to keep better than most other sorts grown here.

I am still selecting and endeavoring to fix the character of a sweet corn which is very promising. It is the cross between the County Gentleman and the Giant, and proves to be of fine-sized ears, fairly early and of robust growth, adapting it to our conditions. Sweet corn is not very highly esteemed in the South because of the general failure of the seed brought here in spring from the North and not

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acclimated. The superior quality of the sugar corns for table use makes it important to get a variety suited to our conditions, and in the variety we have I believe we are succeeding. I hope to distribute a little this year, but do not consider it yet fixed in its character and will select it further.

The variety called Voorhees Red, which was received from the New Jersey Station is rather earlier than ours, but to avoid undesirable mixture we will hereafter confine our attention to the variety bred here.

Muskmelons or canteloupes have also been tested, and nothing better for truckers has been found than the Rocky Ford or Netted Gem, which is the size desired for packing, and is of fine quality.

Incidentally, though not exactly in my line, I have tested some wheat which was sent me from Colorado by Mr. H. M. Curran, one of our graduates now in the forestry work of the Department of Agriculture. The small sample I had of this made a fine growth, and produced some heads that measured seven inches long. It is a bald wheat and was badly injured by a storm when in bloom, and the rust later caused the grain to be rather shrivelled. I have selected the heads measuring from five to seven inches and the general crop, and wish to place the whole in the hands of the Iredell test farm for further experiment.

As heretofore my individual time is almost entirely occupied with the correspondence with the farmers, and I trust that the work done in this way is not the least important work in the Station, for in no other way can we make the Station of greater value to the farmers of the State than by aiding them in every difficulty. I have also prepared articles for the Monthly Bulletin of the Department, and have prepared a pamphlet at the request of the Commissioner of Agriculture for distribution in other states, giving a description of the various sections of the State and their agricultural adaptations. I have also attended and lectured at Farmers' Institutes in various parts of the State, and I held four special Institutes for the negro farmers, two in Raleigh, one in Oxford, and one in Clinton, and had in all these meetings an attendance of about 800. I am of the opinion that much good can be done by the holding of special institutes for the negro farmers and croppers, for few of them come out to our regular institutes.

Owing to the fact that I have not been able to get labor for the work the fruit trees and vines at the Station farm were sprayed but once. My thanks are due to Mr. Jeffrey, the poultryman, for aid in the cultivation of the orchards and in the preparation of spraying materials, and in fact the care of the orchards and the marketing of the fruit I am obliged to largely leave to Mr. Jeffrey. The apple trees have grown well, and the plums are a great success so far as bearing is con-

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cerned, but much more spraying is needed to check their tendency to rot. The red clay soil on which the peach trees were planted is evidently poorly adapted to this fruit. The trees have grown well, but the fruit does not color to a typical shade and is as a rule inferior. Pears have suffered from blight but are getting into bearing. The only variety of blackberries is the Early Harvest, which is early but small in size and of inferior flavor. Grapes are in many varieties, some of which are successful, but many of them rot in spite of spraying, and we have found none better for market than Delaware, Concord and Niagara.

All of which is respectfully submitted,

W. F. MASSEY,
Horticulturist.

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REPORT OF THE BIOLOGICAL DIVISION.

PROF. B. W. KILGORE, *Director.*

DEAR SIR:—As has been the case heretofore, the diseases of plants have commanded the chief attention of the Biologist. Very numerous specimens have been submitted by mail or express, diagnoses made, and treatments prescribed, and in a few cases where the diseases were of especial severity visits have been made to the affected regions.

The asparagus rust, due to *Puccinia Asparagi,* which has so recently been conspicuous as a destructive disease upon the Pacific coast, the presence of which in this State was noted by me in the report of this Station two years ago, is now causing alarm among our asparagus growers. The means of prevention that have proved efficient in California have been recommended, but it yet remains to be seen whether these means will be effective under our climatic conditions.

The powdery mildew of the rose, especially prone to attack the ramblers, has been the subject of frequent inquiry. Instructions for combatting the disease were printed in the agricultural and daily papers, the treatment recommended being as follows: To spray the vines upon the first appearance of mildew with a solution of liver of sulfur (Potassium sulfide) 1 ounce to 3 gallons of water, repeating the spraying as need be. The liver of sulphur is given preference over Bordeaux mixture chiefly because it does not spot the leaves or make them otherwise unsightly.

A disease of sweet potatoes, which for reason of analogy should be known as the Sweet Potato Wilt was found in Pasquotank County. The affected plants show yellow foliage, beginning with the older leaves. The younger leaves then soon wilt and the plants eventually die. The stems and potatoes contain yellowish or blackish strands. Microscopic examination and cultural analysis reveal the constant and usually exclusive presence of a fungus, *Fusarium sp.,* in abundant vegetative and fruiting condition. This fungus belongs to a genus notorious as disease producers, and there is little doubt that it here stands in casual relation to the Sweet Potato Wilt. The fungus has been isolated and is now under cultivation in the laboratory, and it is hoped that inoculation experiments may definitely establish the relation that this fungus bears to the disease.

An apple disease from Watauga County, infecting the bark and causing an appearance which has led me to designate the disease as

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the Apple Scurf, has been the subject of some study. The bark reveals the presence in almost pure culture of a pycnidial fungus. This fungus has been isolated, cultivated and numerous inoculations have been made producing the characteristic malformation. Attempts to inoculate the fruit have as yet failed. Attempts to ascertain the practical importance of this disease have not been made. The fact that it was sent in by an apple grower shows that it is probably of more than academic interest.

The Granville Tobacco Wilt transcends all other agricultural problems in interest and importance in regions where the wilt has gained a foothold. Its control is a matter of such great importance as to justify a complete study and investigation of every clue giving even the slightest hope of ultimate success in the control or prevention of this disease.

There are two obvious methods of attacking the problem: 1. By soil treatment, and 2. by the breeding of a resistant race of tobacco.

Although as yet nearly all attempts at soil treatment in the field have failed in regard to other plant diseases, and the hopes of a successful result were slight indeed, it was deemed wise to make a test of a few of the leading fungicides upon sick soil. That soil sterilization is possible, even if not practicable, is already indicated by the fact that the seed-bed never exhibits the wilt, presumably because the universal practice in these regions involves the burning of much wood on the bed in the process of making, leading to sterilization by the excessive heat. Plats of sick soil of one-fiftieth of an acre each were secured in the spring of 1904, near Creedmoor, on the farm of Mr. Rufus Weathers. That the land the previous year almost utterly failed to produce healthy tobacco is evident from a consultation of the map and photographs of the field published in Bulletin 188 of this Station. The plats were separated from each other by an uncultivated strip four feet wide.

The following soil treatments were made upon these plats:

Plat 4. Ammoniacal copper carbonate, 200 lbs. per acre.
5. Bordeaux Mixture, 2,500 gallons per acre.
6. Copper Acetate, 200 lbs. per acre.
7. Potassium sulfid, 100 lbs. per acre.
8. Formalin, 200 lbs. per acre.
9. Check.
10. Check.
13. Corrosive sublimate, 25 lbs. per acre.
14. Nitrate of soda.
15. Check.
16. Sulfur, 1,000 lbs. per acre.
17. Lime, 4 tons per acre.
18. Copper sulfate, 200 lbs. per acre.

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19. Check.
20. Potassium permangumate.
24. Excess of Potassium.
25. Excess of Phosphorus.
26. Excess of Nitrogen.
27. Excess of Guano.
28. Kainit.
30. Crude carbolic acid, 20 gallons per acre.
31. Iron sulfate, 200 lbs. per acre.
44. Eight per cent Sodium Hydroxide, 1,000 lbs. per acre.
45. Sulfuric acid.

The amount of chemicals used is of course very large, in some cases of prohibitive quantity. These large applications were made in order to make the test a crucial one, with the idea of modifying the amount in succeeding experiments in the event any chemical showed the desired qualities. Many of these treatments showed no appreciable effect. The effects in some cases, were however, noteworthy, as follows:

Plat 4. The color of the tobacco throughout this plat was remarkably green, making the plat conspicuous in the field by its contrast with all adjoining plats. The tobacco had attained greater size than the other plats, and was generally thriftier, but the percentage of plants showing disease or actually dying was about the same as in other plats. At the end of the season the percentage of living plants was 23.

Plat 5. The Bordeaux mixture used on this plat showed no decided effect.

Plat 8. Showed a decided benefit in the percentage of affected plants, but the remedy was by no means complete. At the end of the season 28 per cent of the plants were affected.

Plat 13. The growth was very much retarded, the plants being only about one foot or less in height. Few plants were dying. Only six affected hills were noticed when the field was inspected on July 29th, and 80 per cent of the plants were living at the end of the season.

Plat 18 at the end of the season showed 30 per cent of plants living.

Plat 20 at the end of the season showed 28 per cent of the plants living.

On plats 24 and 25 the percentage of living plants at the end of the season was, respectively, 26 and 24. On plats 26 and 27 each it was 19, though notes taken earlier in the season showed a diametrically opposite result on these two pairs of plats. The results from these plats are especially interesting in view of the idea entertained by many tobacco growers that the wilt is largely attributable to the

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kind or amount of fertilizer used. The large and nearly uniform percentage of wilt found in these four plats seems to indicate that neither an excess of any fertilizer ingredient nor of complete fertilizer serves to materially alter the amount of wilt in the field.

Upon plat 28 the application of kainit dwarfed the plants badly, almost as much so as did the corrosive sublimate, though the amount of wilt seemed unaffected.

Plat 30 wilted as badly as the checks at the beginning of the season; but at the end of the season showed 28 per cent of living plants, apparently a slight benefit.

Plat 31, throughout the season, in color, vigor and resistence, manifested some benefits, while at the end of the season 30 per cent of the plants were unaffected, rather more than on the untreated soil.

Plats 44 and 45 were designed to test the relation of acidity or alkalinity of soil to wilt prevalence.* These plats showed at the end of the season, respectively, 2 and 20 per cent of living plants, a difference too slight to be of real significance, leading to the conclusion that the factor of soil acidity is probably of little or no import.

The check plats throughout the test ranged in number of living plants at harvest from 0 to 29 per cent, in nearly every case falling below eighteen per cent. With the exception of the plats noted above none of the plats showed any definite effect of the treatment applied.

It will be seen that in several cases, notably with ammoniacal copper carbonate, formalin, mercuric chloride, copper sulfate, carbolic acid and iron sulfate there was an appreciable benefit from the treatment, though by no means a benefit so great that any of these chemicals can be regarded as a satisfactory preventative against the wilt. Then, too, the chemical that is most efficient as a preventive, i. e., corrosive sublimate, retards the growth of the plants to an injurious degree.

This test of chemical soil treatment in 1904 has served to eliminate many chemicals from the list of possible remedies. It has demonstrated the indifference of the wilt to acid or alkaline soils, and shown that the excess of nitrogen, phosphorus, potash or guano bears no important relation to the wilt.

It still remains to be determined whether a repeated application on any of these plats may intensify the effect of a first application, and so raise the treatment to a position of practical efficiency.

Other plat treatments intended to determine the longevity of the germ in the soil and the effect of clean or unclean culture are in progress, but are not yet in condition to report upon.

* The normal soil in the field, according to a determination very kindly made by Prof. Withers, requires 84 parts per 10,000 by weight of lime (CaO) to render it neutral. The amount of lime and soda used was more than ample to make the soil alkaline.

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Upon some plats were sown various plants allied to the tobacco plant, and plants known to be susceptible to the various forms of wilts, the object being to determine whether any of these plants are subject to the Granville Wilt. If they are subject to it they of course cannot be profitably raised upon soils upon which the tobacco wilt is prevalent, nor should they be introduced in rotation upon tobacco fields, when elimination of the disease is the aim of the rotation. Should any weeds prove susceptible, such should be most carefully kept in subjection in order that they may not serve as multiplying places for the wilt germ. Plants tested as to their susceptibility were as follows: Pepper, egg-plant, cow-pea, watermelon, cotton, Irish potato, tomato, Physalis, Solanum, Carolinianum and Jimson weed. The cow-pea, melon and cotton, though all subject to a wilt caused by a species of fungus, as well as the horse-nettle and Jimson weed, were completely unaffected, rendering it extremely probable that these plants are immune to the wilt.

Both Irish potatoes and the tomatoes were affected and died prematurely with a stem disease in all appearance like the tobacco wilt. While the identity of this disease with the tobacco disease was not demonstrated by microscopic and cultural methods, the close relation of these plants to the tobacco plant renders it strongly presumptive that the three plants are subject to the one disease.

Among the peppers, one plant, and among the egg plant, two plants, were found showing symptoms of a wilt very similar to that of the tobacco wilt. While the identity of these diseases upon tobacco, Irish potato, tomato, egg-plant and pepper is not demonstrated it is probable that soil upon which one of these crops wilts will cause wilt in the others, (though the egg-plant and pepper are less susceptible), and to attempt to grow them upon fields known to be affected merely means to increase the infection.

With the hopes of finding some means of killing the germs in the soil electrically an apparatus was devised by means of which a powerful current could be passed through a layer of soil of known thickness. Sterilized soil from the Granville region was placed in the apparatus, then upon this soil was poured a culture of a non-sporing organism, and full strength of the current from the college dynamo was applied. Plates were made from the soil, both before and after the passage of the current. In no case could any diminution in the number of living germs due to the electric application be noted. The current was much more powerful than could be used in field practice, and fully demonstrated the impracticability of such electrical treatment.

Many investigators have experimented and written upon the effect of the electric current upon bacteria with a general concurrence of opinion that when any fatal effect is noted it is attributable to the

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products of the electric action, to the heat or chemicals produced, rather than to the current itself, and the conclusion is commonly drawn that the current itself is without effect upon bacteria. This conclusion seems to the writer unwarranted, since no evidence has been advanced to show that the current actually applied really does pass through the organism at all. It is customary to apply the current to the medium containing the bacteria. This medium is usually liquid or at least very moist, and containing salts in solution is a better electric conductor than the organisms, and itself carries the current. Under such conditions the current no more passes through the bacteria than an electric current passing through a river would pass through the fish in the river. Such experiments, including my own, justify no conclusion further than that a current passed through a medium containing the bacteria does not kill or injure the bacteria. Whether a current if actually passed through these organisms would injure them is an entirely different matter, one most difficult to experiment upon, and one which as yet seems not to have been adequately investigated. The practical phase of the present question seems, however, to have been sufficiently examined in the experiments above mentioned.

The most promising means of overcoming the Granville Tobacco Wilt is probably that of developing by breeding and selection a resistant variety or race. The attainment of a similar end in the case of the cotton, cow-pea and tomato gives strong promise of success with the disease under discussion.

The steps in the development of a disease resistant race are 1st: To test existing varieties in order to ascertain whether any race now known is resistant. In event such a race is not found to either, 2d, select the most resistant individuals from the least susceptible race, and by repeating this selection year by year to intensify the character of resistance, or 3d, if no variety now known be at all resistant, to induce variation by some of the means known to plant breeders, such as changed environment, hybridization, etc., and then proceed with seed selection as in 2, or to cross a non-resistant variety upon some kind that is resistant and then proceed as in 2.

In event of the adoption of the steps 3 or 4 a number of years will be required to perfect and "fix" the variety in such a way as to render it commercially profitable. In any event to eliminate a disease by breeding is a long, tedious process. It requires patience, perseverance and skill, and it must be remembered that no certainty, only a fair presumption, of success obtains. The magnitude of the loss occasioned by the Granville Tobacco Wilt, coupled with the certainty that continually increasing areas are laid under its tribute, warrant the attempt to breed a race resistant to its attack.

The first steps in the direction have been taken. Sixty-two Ameri-

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can varieties of tobacco were tested upon sick soil in 1904. The varieties comprised are as follows:

Comstock Spanish.
Flannagan.
Yellow Pryor, Ragland's Improved.
Big Oronoco.
Persian Rose.
Cuban Seed Leaf.
Little Oronoco.
Famous.
Honduras.
Connecticut Seed Leaf.
Sweet Oronoco.
Ragland's Improved Hester.
Hyco.
Yellow Oronoco, Ragland's Improved.
White Stem Oronoco, Ragland's Improved.
White stem Oronoco.
White Burley.
Long Leaf Gooch.
One Sucker.
Pennslyvania Seed Leaf.
Perfume of Italy.
Turkish.
Vuelta de Abajo, 2d crop.
Missouri Broad Leaf.
Tuckahoe.
Vuelta de Abajo, 1st crop.
Zemmer's Spanish.
Medley Pryor.
Gooch.
Bright Yellow.
Brazilian.
Long Leaf Gooch.
Bonanza.
Granville County Yellow.
Climax.
Evans.
Sterling.
Tennessee Red.
Gold Finder.
Pumpelly.
Blue Pryor.
Havana Seed Leaf.
Big Havana.
Maryland.
Lacks.
Easter Pride.
Bradley.
Yellow Pryor.
Little Oronoco, Ragland's Improved.
Yellow Oronoco.
Choice Havana.
Warne.
Harby.
General Grant.
Tilley.
Gold Leaf.
Clardy.
Kentucky.
Yellow Mammoth.
Conqueror.
Hester.
Sumatra.

Sixty-five plants of each variety were set upon a field in which every plant died of the wilt the preceding year. The results of the test are exhibited in the following table:

Unfortunately owing to heavy rains while the plants were in the seed-bed the names of a few varieties were rendered unreliable. These varieties are designated by numbers and the letter X.

Variety.	No. of Hills Planted.	No. of Hills Living.	Per Cent Living.
No. 33, Bradley	65	11	.16
38, Pennsylvania Seed Leaf	65	19	.29
No. 17, Sterling	65	29	.44
No.12, Famous	65	13	.20
Flannagan	65	13	.20
Granville County Yellow	65	17	.26
No. 18, Tennessee Red	65	6	.09
Conqueror	65	2	.03
No. 35, Little Oronoco	65	4	.06
Tilley	65	4	.06

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Varitey.	No. of Hills Planted.	No. of Hills Living.	Per Cent Living.
X	65	6	.09
X	65	1	.01
No. 30, Long Leaf Gooch	65	16	.24
X	65	6	.09
X	65	6	.09
Gold Leaf	65	11	.16
Lacks	65	6	.09
No. 11, Little Oronoco	65	8	.12
Hester	65	6	.09
Evans	65	5	.07
X	65	0	.00
Maryland	65	1	.01
Kentucky Yellow	65	1	.01
White Stem Oronoco Ragland Improved	65	4	.06
Choice Havana	65	3	.04
X	65	6	.09
Brazillian	65	5	.07
X	65	4	.06
Tuckahoe	65	5	.07
X	65	6	.09
X	65	3	.04
Sumatra	65	15	.23
Climax	65	5	.07
32, X	65	18	.27
Eastern Pride	65	3	.04
Turkish	65	12	.18
X	65	2	.03
Bonanza	65	5	.07
Big Havana	65	3	.04
Havana Seed Leaf	65	2	.03
Persian Rose	65	5	.07
Perfume of Italy	65	0	.00
X	65	3	.04
Warne	65	5	.07
Medley Prior	65	4	.06
Yellow Oronoco	65	4	.06
Junius Spanish	65	0	.00
Blue Prior	65	0	.00
Comstock Spanish	65	2	.03
Hyco	65	3	.04
General Grant	65	11	.16
Yellow Prior	65	8	.12
Xy	65	8	.12
Xw	65	7	.10
North Carolina Bright Yellow	65	0	.00
Yellow Mammoth	65	0	.00
X	65	1	.01
X	65	1	.01
29	65	11	.16
13X	65	15	.23
30	65	20	.30
45	65	12	.18

These results may be summarized by separating the varieties tested into seven classes according to the degree of resistance manifested.

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Class 1, of which above 29 per cent lived.
Class 2, of which above 24 but below 29 per cent lived.
Class 3, of which above 19 but below 24 per cent lived.
Class 4, of which above 14 but below 19 per cent lived.
Class 5, of which above 9 but below 14 per cent lived.
Class 6, of which above 4 but below 9 per cent lived.
Class 7, of which below 4 per cent lived.

The varieties falling into each of these classes are given in the table below.

CLASS I.

Above 29 per cent lived.

No. 30, 30 per cent.
No. 17 Sterling, 44 per cent.

CLASS II.

Above 24 per cent.

No. 38 Pa. Seed Leaf, 29 per cent.
No. 32 X, 27 per cent.
Granville Co. Yellow, 26 per cent.

CLASS III.

Above 19 per cent lived.

Sumatra, 23 per cent.
No. 13 X, 23 per cent.
No. 30 Long Leaf Gooch, 24 per cent.
No. 12 Famous, 20 per cent.
Flannagan, 20 per cent.

CLASS IV.

Above 14 per cent lived.

No. 29X, 16 per cent.
No. 45X, 18 per cent.
No. 33 Bradley, 16 per cent.
Gold Leaf, 16 per cent.
Turkish, 18 per cent.
Gen. Grant, 16 per cent.

CLASS V.

Above 9 per cent lived.

No. 7, Little Oronoco, 12 per cent.
Yellow Prior, 12 per cent.
Xy, 11 per cent.
Xw, 10 per cent.

Classes VI and VII contained 42 species, which it is not necessary to enumerate.

Those varieties falling into Classes V, VI and VII showed such

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low resistance that no seed were saved, and the varieties were discarded.

The resistance in Classes I to IV is low, but when compared with that of Classes V to VII there is such difference that the existence of *some* degree of resistance to the wilt in these species is evident. The next step is to determine whether the resistance in any of these varieties can be so increased by selection as to develop a variety that can be grown with profit upon sick soil. Failure to do this would indicate the necessity of developing *new varieties* with which to continue the search as outlined above. Seeds from the most resistant classes named above will make the starting point for the next season's work.

It is rather generally believed throughout the affected tobacco region that the crops introduced into rotation with tobacco play an important part in determining the destructiveness of the disease and its longevity in the soil. As to just what crops are most favorable to the grower there is much difference of opinion; still it seems probable that there is some basis for the current belief. I believe it highly desirable to inaugurate a series of experiments to ascertain the facts in this regard.

The watermelon wilt has been repeatedly referred to in earlier reports and bulletins. This disease is constantly claiming new land in and outside of this State. In many counties in North Carolina the disease has reached such a degree of virulence as to completely destroy the melon shipping industry, and its advance into new regions is rapid.

The work of breeding, by selection and hybridization, a variety of melon that will be resistant to this disease is being continued in cooperation with the Bureau of Plant Industry of the National Department of Agriculture. Some 216 varieties and hybrids of melons were tested upon soil known to be sick. Sixty of these were American varieties, ninety-six Russian and South Carolinian, and fifty-seven were citron hybrids.

For the purpose of originating new varieties, hand crosses were made, in all 537, from which 87 hybrid melons were secured.

Of the established edible varieties, both native and foreign, that were tested, none showed resistance enough to warrant its further test. The hybrids, however, proved more promising. Many of these possessed higher resistance, complete resistance. Among these resistant hybrids there was great variation in quality, many were hard, tasteless and wholly inedible. Others, on the other hand, were of the highest standard of perfection from the commercial point of view. They were sweet, crisp, tender, of good shipping quality and excellent yield. If succeeding years should secure the "fixing" of one or more of these promising varieties already developed as a starting point, the object of the work will be attained.

Respectfully submitted,

F. L. STEVENS,
Biologist.

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REPORT OF THE VETERINARY DIVISION.

MR. B. W. KILGORE, *Director*—

DEAR SIR:—I have the honor to herewith submit the report of the Veterinarian.

No problem now confronting the live stock sanitarians of this country approaches in importance the extermination of the cattle fever tick (Boophilus annulatus) and the removal of the Federal quarantine restrictions from the cattle traffic of the South.

To find a method of eradicating the fever tick that was applicable to existing conditions; that is, a method that could and would be applied by the stock owners of the State, and demonstrate the practicability of ultimate tick extermination, has occupied the attention of the Station Veterinarian for the past four years.

Sufficient work has now been done to not only demonstrate the feasibility of exterminating the fever tick in any given area; but the small cost at which the work has been done also shows that it is easy, practicable and profitable.

In 1902 only sixteen of the Western counties of the State were free from the Federal cattle quarantine restrictions (see Fig. 1, page 37), and of these, three still had a few ticks and one had a great many. In 1906 twenty-six counties and parts of two others (see Fig. 2, page 38) are free of all Federal quarantine restrictions because the ticks within their borders have been exterminated, and the four counties that in 1902 were still infected, but not under Federal quarantine, are also entirely free of ticks.

The ten counties which have been released from all Federal quarantine restrictions, because we have exterminated the fever ticks within their borders, sell about $280,000 worth of cattle annually. If the price of these cattle was reduced only one-fourth cent per pound, it meant an annual loss of one-tenth of $280,000, or $28,000, which is double the entire amount expended in exterminating the ticks in those counties. In other words, any "stock-law" county in North Carolina now under quarantine can be freed of ticks, and as a result exempted from Federal quarantine restrictions, for half the money now lost each year solely because of the presence of the ticks.

Briefly stated, the method of extermination found most applicable to our conditions is as follows: Inspectors are employed who make a farm to farm canvass of the territory with a view to locating all tick-infested farms, which are at once quarantined and the owners carefully instructed as to the importance and object of the work, and especially as to the easiest and best means of exterminating the ticks

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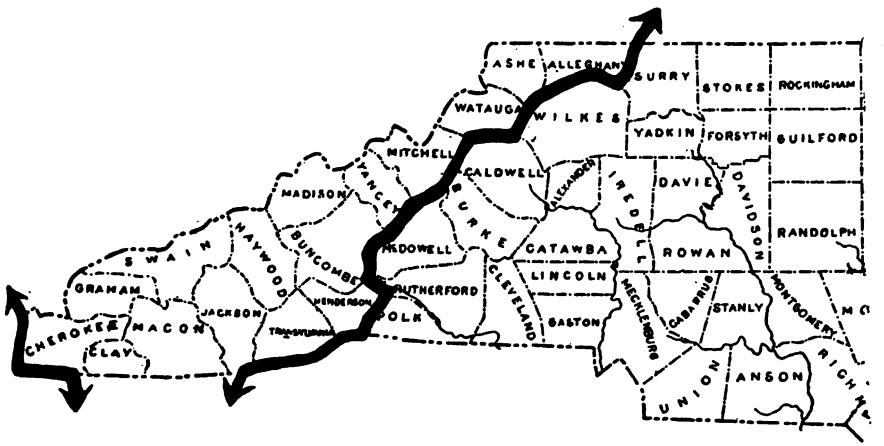

FIG. 1. Federal Quarantine Line across North Carolina, 1902.

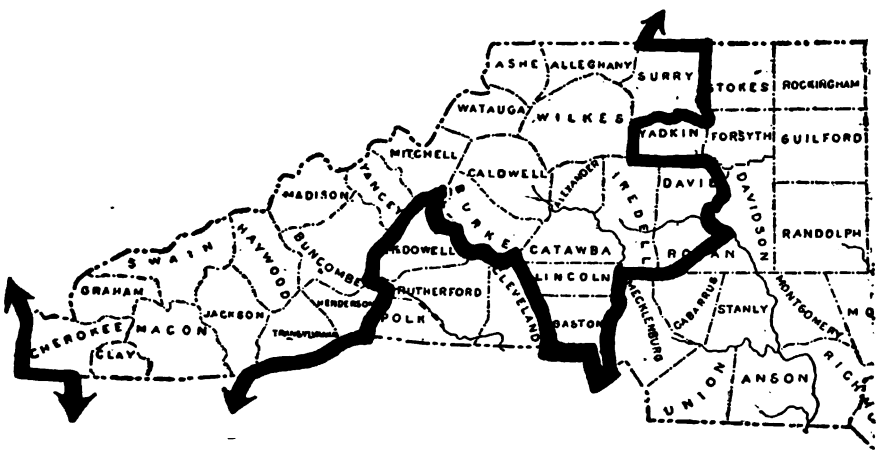

FIG. 2. Federal Quarantine Line across North Carolina, 1906.

on their places. The means of killing the ticks found most practicable in this State is to take all cattle, horses and mules out of the tick-infested pastures, lanes and lots for one season, or from September 1 to May 1 of the following year.

Respectfully submitted,

TAIT BUTLER,
Veterinarian.

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REPORT OF THE POULTRY DIVISION.

PROF. B. W. KILGORE, *Director.*

DEAR SIR:—I beg to submit the following report of the work in the Poultry Division for the year ending June 30, 1905:

I think that perhaps the most encouraging thing that I am able to report at this time is that the Station flock is at last free of roup. This disease for the first two years of my work here was very bad, and not only caused serious financial loss but interfered very much with experimental work.

As a result of the improved health of the flock a larger number of chicks have been hatched and a very much larger percentage of those hatched have been raised to maturity.

The experiments in egg preservation were continued from last year and the results published. The feeding work will need further tests before publication, and I propose to continue this work during the coming year.

Egg records of the different varieties have been kept again this year, and have in some cases reversed the results of last year, Buff Plymouth Rocks and Buff Orpingtons leading, and their superiority was more marked during the winter months when eggs were high-priced than for the whole year.

At the Farmers' Institutes which I attended I found that the branch of poultry raising that the farmers were most interested in was the production of broiler or frying-sized chickens, and I will devote a large part of my time to this the coming winter with a view to being able to give more help along this line of work.

The demand for poultry and eggs of improved breeds the past year has been good, and all the surplus stock has been disposed of to the farmers of the State, and this distribution of improved stock will soon show in a lessening of the difference in price between Southern and Western poultry in the Northern markets.

The correspondence of this division continues to increase rapidly, and my duties as Secretary of the State Poultry Association add very largely to this part of my work.

We have added one variety of fowls to those already kept, and now have good representatives of the following varieties: Barred, Buff and White Plymouth Rocks, White and Buff Wyandottes, Light Brahmas, Buff Orpingtons, White and Brown Leghorns and Black Minorcas.

In building the new houses needed, I will test a cheaper house than the Scratching Shed House built two years ago, as I find that many

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farmers object to it on the ground of the expense of building it. These houses will also have two yards to each, so that we can keep the fowls in the same quarters the whole year and have green food in the yards for them most of the year by growing a crop in one yard while the fowls have the other. This arrangement will greatly facilitate the work of keeping egg records for the whole year, and will also give us a chance to test the value of green food.

Respectfully submitted,

J. S. JEFFREY,
Poultryman.

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REPORT OF ENTOMOLOGIST.

DIRECTOR B. W. KILGORE, *Raleigh, N. C.*

DEAR SIR:—The work of the Division of Entomology as applied to Station affairs for the year ending June 30th, is briefly summarized below.

As has been pointed out in previous reports, the expense of maintaining and equipping the office of the Entomologist has been entirely borne by the State Department of Agriculture, hence practically all of the work done is accounted for in the semi-annual reports to the Agricultural Boards.

During the year all inquiries concerning insect pests which have been addressed to the Station have been referred to this office and have been carefully answered.

Work with the Experiment Station orchard, especially pertaining to the San Jose Scale was this year turned over to Professor Massey, and hence there is nothing to be reported from this office in connection therewith.

A start was made towards installing the few swarms of bees at the Experiment Station in modern hives, in order that we might make some comparative tests in honey products. This work was interrupted by the sudden resignation of Mr. Bentley, the assistant, to accept an appointment in Tennessee, and has not yet been taken up. We hope that we shall be able to do something in this line after the conclusion of the inspection work.

Very truly yours,

FRANKLIN SHERMAN, JR.,
Entomologist.

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NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATION, 1904—1905.

DR.

To receipts from the Treasurer of the United States as per appropriation for the fiscal year ending June 30, 1905, as per act of Congress approved March 2, 1887 ..... $15,000.00

CR.

By Salaries	$9,685.32	
Labor	1,770.97	
Publications	545.75	
Postage and stationery	380.91	
Freight and express	109.76	
Heat, light, and water	43.51	
Chemical supplies	100.45	
Seeds, plants, and sundry supplies	374.43	
Fertilizers	334.87	
Feeding stuffs	485.88	
Library	22.62	
Tools, implements, and machinery	381.31	
Furniture and fixtures	31.13	
Scientific apparatus	62.53	
Live stock	174.85	
Traveling expenses	295.25	
Contingent expenses	96.92	
Buildings and repairs	104.04	
Total		15,000.00

We, the undersigned, duly appointed auditors of the Corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1905, that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000.00, and the corresponding disbursements $15,000.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress, approved March 2, 1887.

(Signed.) S. L. PATTERSON;
[Seal.] B. W. KILGORE,
Auditors

Attest: A. F. BOWEN, *Custodian*.

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Bulletin No. 190. **May, 1905.**

NORTH CAROLINA

Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts

RALEIGH

The Formation of Nitrates in the Soil.

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N. C.-COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

S. L. PATTERSON, *ex officio* Chairman, Raleigh.

J. M. FOREHAND.....Rockyhock	A. T. MCCALLUM .....Red Springs
J. B. STOKES .....Windsor	J. P. MCRAE .....Laurinburg
WM. DUNN.....New Bern	R. L. DOUGHTON.....Laurel Springs
C. N. ALLEN.....Auburn	S. T. WILFONG.....Newton.
R. W. SCOTT.....Melville	A. CANNON.....Horse Shoe

STATION STAFF.

GEO. T. WINSTON, LL. D., President of the College.

B. W. KILGORE.....Director.
W. A. WITHERS .....Chemist.
W. F. MASSEY.....Horticulturist.
C. W. BURKETT.....Agriculturist.
TAIT BUTLER .....Veterinarian.
F. L. STEVENS.....Biologist.
FRANKLIN SHERMAN, Jr.....Entomologist.
CHARLES WALKER .....Assistant Chemist.
J. S. JEFFREY .....Poultryman.
B. F. WALTON.....Assistant in Field Experiments.
J. C. KENDALL.....Assistant Dairy Husbandry.
A. F. BOWEN .....Bursar.

The Director's office is in the Agricultural Building, Raleigh; the experiment grounds and laboratories being at the Agricultural College just west of town and on the street car line.

Visitors will be welcome at all times and will be given every opportunity to inspect the work of the Station. Bulletins and reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

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Farm Dairying.

By J. C. Kendall.

The interest which is being taken in dairying, and the constant demand for information along this line has led us to believe that a Bulletin discussing in a general way the topics of the most vital interest to the dairymen of the State, as well as the farmer with only a few cows, would be acceptable at this time. Other stations have issued works bearing on this subject, but such information is not always accessible to the residents of this State, and many times it does not apply to our conditions. It is therefore with the hope of assisting to bring about a better understanding of the most approved methods of handling dairy products, as well as a much needed improvement in the products of our dairies, that this Bulletin is issued.

It is often the simplest things that are of the greatest importance. And this applies with special force to dairying. The man who can not or will not pay attention to the hundred and one details connected with the dairy might just as well look for some other occupation. It is not alone in the performance of these little duties that all of the importance lies. It is of like importance that they be done thoroughly and at the proper time. In other words, the dairyman must be a thorough and systematic man, or his business must suffer. We speak of these things at this time because it is the little things connected with our work that are sure to cause the most trouble, and furnish our excuse for the many details of this Bulletin.

Present and Future Prospects in Dairying.

By referring to the last census report it is found that few States have made equal progress with North Carolina in the improvement of her live stock, and more especially her dairy cows. While the average yearly production is low, it has been improved in a striking manner. With the exception of Tennessee there is not another Southern State that can show as large an average production of milk per cow as North Carolina. It is not only in dairying that this State is forging ahead, but along all lines of agriculture. And with this advancement comes an ever increasing demand for agricultural knowledge.

We realize that North Carolina has not been and is not now classed as a dairy State. And yet dairying is by no means least of her varied industries. North Carolina has 224,637 farms, nearly as many as New York State, and on these farms are kept 233,178

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dairy cows, valued at $4,426,709. This State ranks 25th among the 52 States and Territories in the value of her dairy products. According to the last census report the dairy products for that year were valued at $6,175,397, which shows dairying to be even under existing conditions no mean industry. It is equal to nearly twice the value of the wheat crop, more than half the tobacco crop, and more than a third of the cotton crop.

In spite of the progress that has been made, we are compelled to meet the conditions as they exist, and admit that they are far from what we could wish. At present over the larger part of the State dairying exists merely as a side issue to the general work of the farm. On most farms are kept a few cows of no particular breed or breeding, to furnish the family with milk and butter. Beyond that little attention is given to this line of work. It is quite a common practice to let the calf strip the cow after milking a little of the fore milk. That means that the cow is worth only about half of her value as a dairy cow and the farmer is using the poor milk and the calf is getting the cream. Whole milk is often churned at the expense of time, amount, and quality of butter. It is not an uncommon thing for milk and cream to be kept in the living-room with little if any protection from the many detrimental influences that are sure to exist. Butter, when sold at the grocery store, brings scarcely enough to pay for the labor involved because of some defect. There is a demand and an urgent demand for better methods, better facilities, more and better stock, and more and better daily products of all kinds. Here and there about the State are located dairymen who are making dairying a specialty, and are taking advantage of modern methods, and making a study of this work. Such men are forecasting the possibilities for successful dairying in North Carolina.

The prospects for dairying in the South are rapidly improving. New business is coming in and with it comes the varied and diversified industries that always follow in its wake. The cotton manufacturing of New England is coming South, and new industries are springing up all along the line. This means more people, larger cities with their accompanying demands upon the husbandman, as never before, to furnish a great variety of food and more and better products of every kind. And the great question arises, will we be equal to the occasion? Shall the sons of North Carolina prepare themselves to meet these demands, or will they wait and calmly watch the outsider come in and take possession of the land and the prosperity that should be theirs?

North Carolina is blessed with the natural conditions for a large and successful dairy industry. Mild climate, requiring inexpensive buildings and live stock shelters, long and favorable growing seasons for growing forage crops. Cattle can be pastured nearly the year

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round; cotton-seed meal, one of the cheapest and best concentrates for dairy cows, is right at our door; large yields of practically every forage crop can be produced, and at the same time improve our land and lighten one of the biggest drains on our profits: the fertilizer bill. And together with everything that goes to make cheap production possible, comes the home market for all kinds of dairy products at high prices. Cheap production with a ready market are the two requisites of a profitable business.

Thousands of pounds of butter and butter substitutes are annually shipped into all of our larger towns. In fact all of the large markets are controlled by shipments from outside of the State. We hold that this state of affairs should not be allowed to exist. There is no reason why our farmers should not receive the profit to be derived from this source, thereby increasing their prosperity and the general prosperity that always follows the establishment of a successful animal industry.

Partly due to the fact that it is not known to exist, and partly due to the lack of a proper understanding of how to make and ship good butter, we have this situation. In a part of the State that can not be surpassed for its natural adaptability for dairying in the United States, butter is selling for *eight and ten cents* per pound, while in other sections and over the largest part of the State, ordinary butter sells at from 25 to 30 cents a pound, and real good butter can scarcely be bought on the open market for any price. The natural dairy districts should supply these large markets that are now controlled by Western and Northern creameries. Surely our railroads are not so exorbitant as to charge us as much to take butter part way across the State as it costs to ship butter from its present source, Kansas, Illinois, Vermont, and other distant States.

If it is necessary in order to furnish a sufficient quantity of butter of uniform quality to command these large markets, let a few dairymen cooperate in this work, take the milk to some central point and then let it be handled by some person who understands the work and where appliances especially designed for the work can be supplied. Instead of each small dairyman having a separate churn, butter worker, boiler and going to other expenses, reduce the cost by uniting in one outfit. This is a day of combination of both labor and capital, and how can the farmer hope to compete unless he also unites with his neighbor in an effort to reduce the cost of production and transportation.

The future prospects for dairying in North Carolina appear very promising. And one of two things must take place. We must fit ourselves to carry on this line of work or people from other States are coming here and carry it on for us. It is evident that we can not afford to continue shipping cotton-seed meal to other States, no better,

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if as well adapted to this industry, and bring back our butter. We need this varied and diversified agriculture in order that our work may be more uniformly distributed throughout the year, thereby solving to a certain extent some of our labor problems. We need just such cultivation and rotation of crops as this work demands in order to realize our best returns from the so-called money crops and to make the most from our land.

One-crop farming is demoralizing. Failure of crops, fluctuations in prices, together with the evils attendant upon the credit system, make this kind of farming unsuited for the small farmer. The farmer will go into debt basing his ability to pay on a large crop at high prices. If either of these, or, what sometimes happens, both fail, hardship, with its accompanying evils, follow.

THE COW.

The dairy business rests upon that most variable of foundations, the cow. And the kind of business and the profits to be derived therefrom are very largely dependent upon the adaptability of the cow for her work. The profitable cow is the one that is capable of turning the largest amount of food into milk and butter. In order that she may handle a large amount of crude material and change it into a finished product, requires special characteristics peculiar only to a dairy cow. While the most experienced judge of dairy stock can not by observation always pick out the prize winner, he can be greatly aided by a proper understanding of the requisites of a dairy cow. The profitable animal is not to be found in any particular strain or breed. Pedigree does not necessarily mean ability. Individual merit is the only safe and true guide in selecting animals for our herd.

Whatever our business, unless it is successful we lose interest in it and become discouraged. How can we hope to be successful if we continue to feed and care for, year after year, cows that do not pay for the food that they consume? We would not tolerate theft in man. Why should we submit to the constant inroads upon our profits by those profit parasites, the scrub?

We must, therefore, if we hope to meet with a fair measure of success in the dairy business, practice the most rigid selection of those animals designed to found our herd. Breeding animals must be of the very best we are able to obtain. Especially is this true of the sire. Purchasing a bull for a little less money does not mean practicing economy: if it means an inferior animal it is a very grave mistake, and one that is not easy to correct. Make sure that he has the proper conformation and quality, and the record of his ancestors is all that could be desired. This latter is very important since another wise superior animal may not produce good offspring, unless

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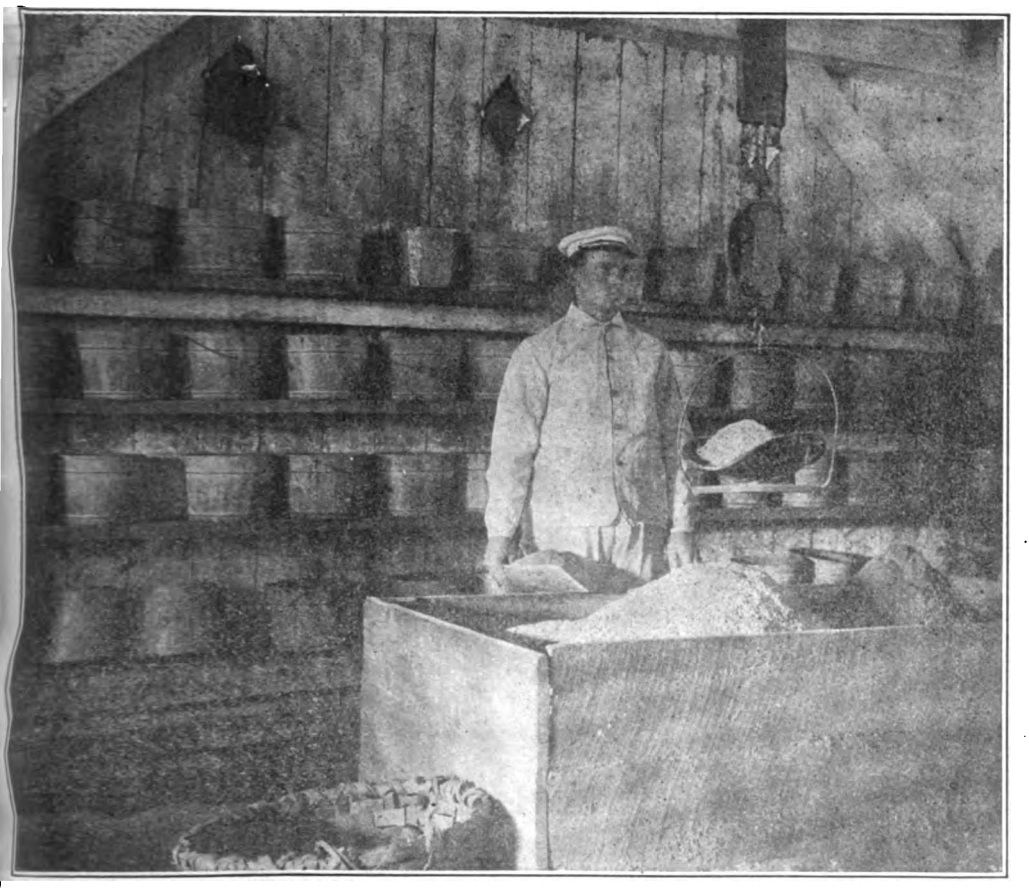
backed by a long line of successful performers. Of course in the selection of an old bull his progeny is even a safer guide to his value as head of the herd.

Make a standard of performance that you will expect each indi-



METHOD OF WEIGHING GRAIN RATIONS.

vidual to reach, and unless this standard is reached let them go to the butcher. Stable space is too valuable, food too expensive, and life too short to be spent in caring for animals that will not return a good profit, and by proper care in selecting and breeding this standard of excellence can be gradually raised. We have in mind a case where a dairyman started with his standard at 300 pounds of butter as an average for his herd. Last year that herd averaged over 500 pounds of butter, and still this progressive man is not satisfied.

Business methods pay in dairying and every progressive dairyman

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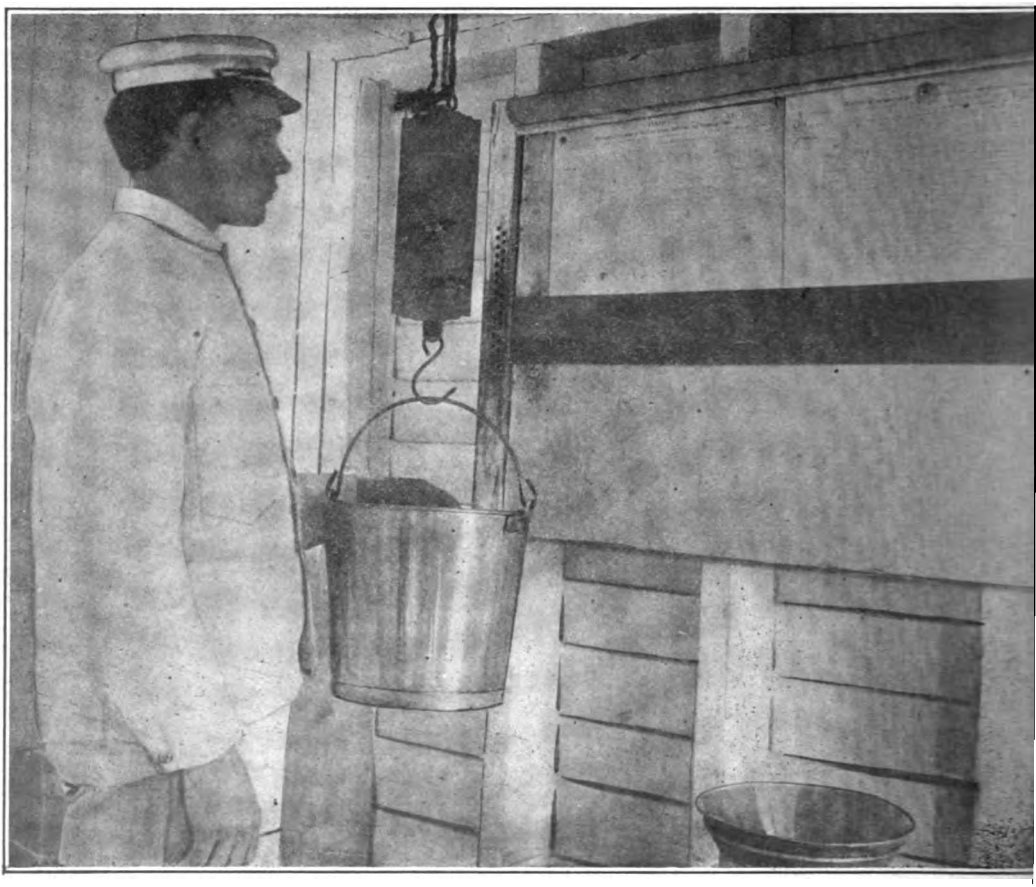
should keep accurate records of all transactions and hold each cow to a strict account for the food she consumes. The milk from each cow should be weighed every milking. This requires but very little time. All that is necessary is a spring balance weighing pounds and



WEIGHING AND RECORDING MILK YIELD.

tenths, and a piece of ruled paper. Write the cow's name at the top of the sheet and the date on the margin of the left side. If to this record there is added the fat test record for each cow, her value as a butter cow will also be ascertained. All that is necessary to make this test is to have a pint jar with a lid, and take a very small sample of the milk from each milking after it has been poured back and forth from one pail to another. This is necessary because the cream tends to rise even during milking, and simply stirring the milk has been found to give too high a test. These samples should be taken

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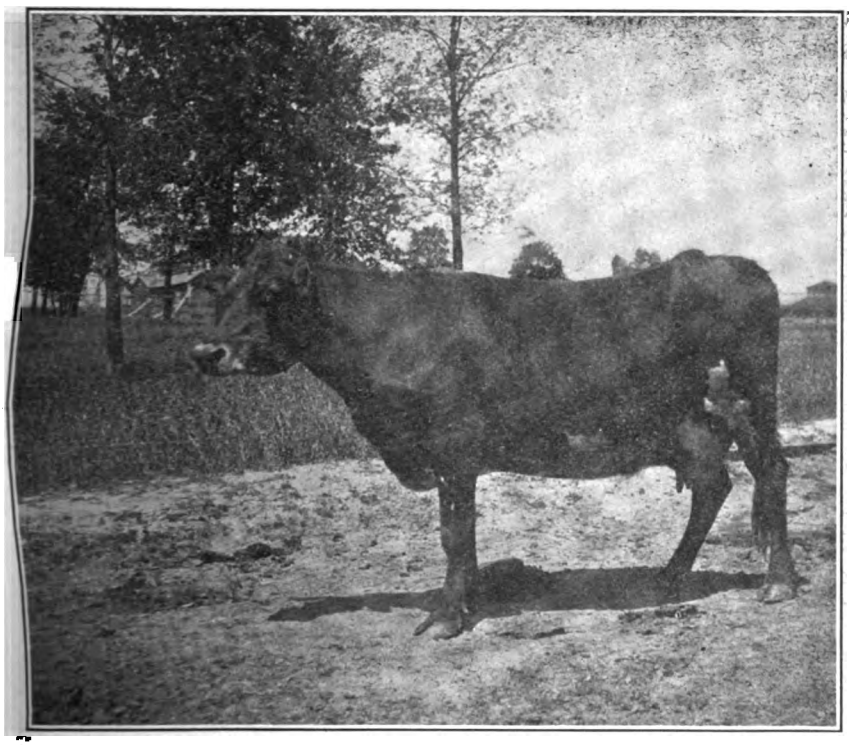
from at least four milkings to avoid any errors that might occur from taking a single sample by reason of the health of the animal or some of the causes that produce changes in the fat content. The samples that have been kept covered in the jar are then taken and tested for fat by the Babcock test. The Babcock test is a simple but reliable



MARY: ILLUSTRATES A GOOD DAIRY TYPE

test and anyone will be able to make the test from the directions sent out with the tester. Testers for making from 2 to 8 tests can be bought for from $4.50 to $9.00.

If to the fat and milk record can be added the amount and cost of food consumed by each animal, it is a simple matter to tell what it has cost to keep each animal and what she has given in return both as milk and butter. Such records are invaluable as guides in the selection and disposition of individuals of the herd. For example, take some of the records of the College herd, and we can see the great advantage to be derived from such records.

Mary in one year produced 6,387 pounds of milk, 358 pounds of butter, and gave a profit over food consumed of $60.94 from the sale

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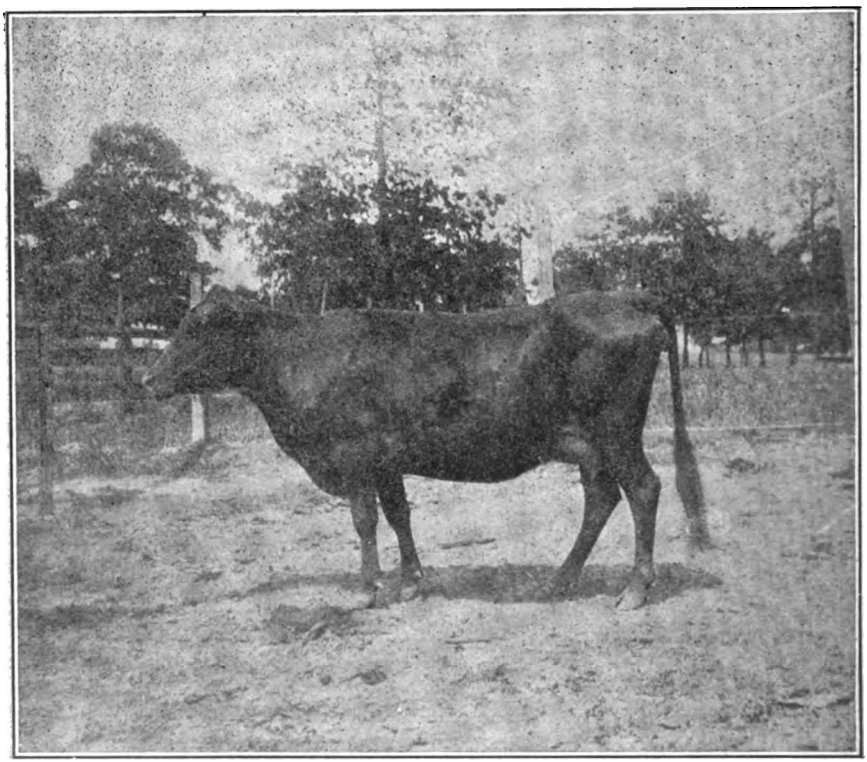
of the butter. Chatham produced in one year 3,867 pounds of milk and 204.2 pounds of butter, and gave a profit of $20.43 over cost of food consumed. In other words, Mary was worth to us practically as much as three cows like Chatham. These are not extreme cases, but samples taken at random. We could show records of cows in our



CHATHAM: ILLUSTRATES A POOR DAIRY TYPE AND AN UNPROFITABLE COW.

herd that have produced as much profit as five other cows. It does not look very business-like to milk and care for a herd of 27 cows like Chatham when we could realize as much from milking and caring for nine cows like Mary. We must bring business methods to bear on our work. One reason why business men who take up agriculture are successful in spite of the fact that their knowledge of the subject may be quite limited is because they continue to use business methods.

Good milk can be obtained from only healthy animals. Cows can be kept in good health by being housed in light, well ventilated stables. The keeping of any but healthy animals for furnishing that life-giving fluid that often serves as the sole food for children and

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invalids can not be too severely condemned. The shelter for the dairy cow need not be elaborate, but permit of easy cleaning and furnish plenty of light and air, besides affording proper protection from all kinds of weather. As far as possible the inside of a barn should have a smooth surface, and several times a year should receive a coat of whitewash. This treatment not only preserves the wood and lightens the stable, but also serves as an antiseptic.

MILK.

"What a wonderful thing is milk! born of a mother's love, it nourishes the young of all warm-blooded creatures, whose term of life would quickly end were it wanting. From the lowest animal to noble man, milk is for all the flesh builder, the nerve power, the very essence of life. It is the one product all indispensable, universal."

Good milk is one of the best and most healthful foods known to man. And when we compare its cost with its food value we find that it is also a very cheap food. Few meals indeed that does not see milk or some of its products upon the table. And yet few realize its true value. A quart of good milk contains nearly as much food value as a pound of sirloin steak, and is very much easier to digest.

Normal milk is slightly heavier than water, and consists of minute fat globules in a watery solution of sugar, albumen, and ash. The fat globules are very small, varying in size from 1-1500 to 1-45000 of an inch in diameter. The fat is the most variable constituent of milk. The average per cent of fat is supposed to be about 3.7 per cent. The average test of milk in North Carolina would very likely be much higher than that. The milk from the college herd tests very close to 5 per cent. While the fat contents from individuals may vary, the fat content of milk from a herd remains quite constant.

When a cow is giving her maximum yield shortly after parturition, her milk is usually of lowest fat content. From then until the end of her lactation period a gradual change takes place in the size, number, kind, and per cent of fat. Sometimes the milk will test a per cent higher at the end of the milking period than it did at first.

There is a marked variation in the amount of fat in the fore milk and the "strippings" or last drawn. The former being a little better than skim milk and the latter practically cream.

Some breeds of cattle naturally give richer milk than others. The Guernseys and Jerseys give milk that is very rich in fat and highly colored. The Ayershire and Holstein breeds are noted more for large yields of milk rather than for its quality.

Cows receiving proper care and food will not, contrary to popular opinion, change materially the per cent of fat of their milk by changing their food. In other words, we can not feed fat to cows and get an increased amount of fat in milk. The quality of the milk

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from a cow is as normal to her as the color of her hair. The increased yield obtained when cows are given a change in food is due to the increased flow of milk rather than to a change in its composition.

Milk when properly handled and cared for is one of the most healthy and wholesome of foods. When it does not receive proper attention it may become one of the most dangerous of foods, and especially since it is used largely as a food for children and invalids. Quite a large per cent of ills babies are heir to can undoubtedly be traced directly or indirectly to the milk supply. It is not the well-known diseases such as tuberculosis, typhoid fever, scarlet fever, and diphtheria alone that we have to fear in connection with milk. There is little doubt that some three-score epidemics can be traced to a contaminated milk supply. Yet they are comparatively rare in occurrence and we believe of comparative insignificance when compared with the so-called minor ills of children such as cholera infantum, diarrhœa, and many similar troubles that may be the result of using impure milk. The necessity for using every precaution possible in caring for milk is apparent when we consider that otherwise life itself may pay the penalty.

MILKING.

The saying, prevention is better than cure, applies with special force to the care of dairy products, and along this line we would offer the following suggestions:

The stable should supply an abundance of light and be kept clean, and free from dust and odors. The walls should be frequently whitewashed, not only to improve their looks but to make the quarters lighter and more sanitary. The whitewash acts as an antiseptic. Dusty food or food with strong odors should not be fed within several hours of milking time. Sweeping the stable before milking is objectionable.

The cow should be carded and brushed regularly to keep her in clean, healthy condition. There is no reason why we should not take just as much pride in having the coat of our Jerseys as slick and clean as that of our driving horses, and in fact a great deal more so, for it is to her that we have to look for part of our food. Besides, it is while the milking is taking place that most of the impurities gain an entrance to the milk. The cow will do her part and secrete a clean, pure milk, and it is our duty to see that it remains so. There are two very practical methods of reducing the amount of hair, dust and filth that ordinarily falls into the milk at this stage: By giving the flanks of the animal and the udder a good washing and then wiping dry just before milking; the other, and probably the most satisfactory method, is to wipe the udder and adjacent parts with a damp cloth. The cloth should not be so wet that the water will run into

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the pail, because that would be worse than no treatment, but just moist enough to remove or prevent from dropping into the milk the loose hair, scales and dust that are always present. This requires but a very few minutes each time, and has been proved to be quite effective in improving the keeping quality of the milk. We quote the following from "Dairy Bacteriology": "When the animal was milked without any special precautions being taken, there were 3,250 bacterial germs per minute deposited on an area equal to the exposed top of a ten-inch milk pail. Where the cow received the precautionary treatment as suggested above, there were only 115 germs per minute deposited on the same area."

The milker should be clean in person and clothes. Instead of putting on the dirtiest clothes to do the milking, clean, white suits that are frequently washed should be used. The milking should be done with clean hands. It is hard to imagine a more filthy practice than moistening the hands with milk. The milker should keep in mind that he is handling an article of food and treat it as such.

Milk pails are a source of trouble when not properly treated. There are a great many kinds of pails on the market designed to aid the dairyman in his warfare against germs. The most improved pail that is used in sanitary dairies is the covered pail, having a layer of absorbent cotton between two layers of fine wire gauze, through which the milk must pass before it enters the pail. Others have the top largely covered, leaving a circular opening for the milk to pass through an inserted strainer. Such pails are more difficult to clean and are not as convenient for the milker. A milk pail free from bad joints, or, what is to be preferred, a pressed tin pail without joints, that has been thoroughly washed and scalded is, on the whole, about as satisfactory as any.

As soon as possible after being drawn the milk should be removed from the stable and strained through four thicknesses of cheese cloth, or through a wire gauze strainer designed for the purpose and through two thicknesses of cheese cloth. Where small strainers are used it is not advisable to use the same strainer cloth a second time. They are very difficult to clean properly and the cheese cloth is so cheap (4 to 5 cents a yard) that it does not pay to try to clean them in view of the danger from using a dirty strainer.

If the milk is to be separated it should be done at once while it is warm. This can be done in a small room adjoining the stable, provided it is sealed up, kept clean and used only for handling milk. A little whitewash will give such a room a neat, tidy appearance. Such a room can be used for weighing, straining, keeping records of the herd, and separating the milk, and saves the labor of carrying the whole milk to the house or dairy and then bringing back the skim milk for feeding purposes. The skim milk can be fed at once

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while it is warm and in the very best condition for feeding pigs and calves. If this method is used only the cream need be taken to the house or dairy, where only a small room set apart for the ripening of cream, churning and printing butter is necessary.

If the milk is not separated and is to be delivered as whole milk, then some means whereby the milk can be quickly cooled must be provided. This is of the utmost importance if we expect milk to remain sweet for a long time. Proper attention to this part of the work may save one trip in delivery. Night's milk, properly cooled and bottled and kept cold, is in better condition when it reaches the consumer than morning's milk, that has been allowed to cool naturally on the wagon, and will generally keep several hours longer during the summer months. The reason for this is very easy to see when we consider that the temperature of milk as it is drawn is more favorable for rapid bacterial growth, and even though the number of germs present at first be comparatively small, this multiplication takes place so rapidly that it is only a question of a few hours until the progeny of each germ will number way up in the thousands. In order to test this point in a practical way the following experiments were performed: Some samples of the same milk were placed in bottles that had been thoroughly cleaned, and kept under exactly the same conditions except that the milk in some of the bottles was cooled quickly and thoroughly, and in the others allowed to cool naturally at room temperature. The milk that was cooled kept on an average eleven hours longer than the uncooled milk. This is long enough to determine between good and poor milk looking at it from the patron's standpoint.

AERATING AND COOLING.

Aerating milk is the best method of cooling the milk when it is done over a combined aerator and cooler. The warm milk is allowed to flow in a thin layer over a cooled surface, the odors or gases at the same time passing off. There are a great many different styles of aerators and coolers. One of the best aerators is the star aerator. It consists of a corrugated surface over which the milk flows and on the inside of which a stream of cold water or brine is running. The milk is cooled in this way within a degree or two of the temperature of the water.

RETAILING MILK.

Milk for the retail trade should be delivered in glass bottles. Bottles without any metal attached are to be preferred. Pulp caps that have been dipped in paraffine are used for closing the bottles. Metal caps are always getting out of repair, besides being difficult to keep clean.

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The practice of delivering from large cans is objectionable, as there is always so much dust and dirt flowing about in the city streets, besides the injustice done the consumer by the unequal distribution of the fat in the milk.

It is coming to be the practice among milk dealers to standardize milk. It is first run through a separator, then mixed to a certain per cent of fat, generally four per cent. Passing the milk through a separator is a cleansing process, and if the cream and skim milk are mixed thoroughly together at once the milk is improved. The fat does not rise to the surface as quickly or as thoroughly as in unseparated milk. This is an advantage except that the patrons may think that the milk is not quite as rich if there is not as thick a layer of cream on top of the milk.

Certified milk is milk that has been given special attention as to its purity and long keeping qualities, and is produced under sanitary conditions. This business is backed by a physician's certificate guaranteeing its purity. Such milk is used for feeding children and invalids, and generally brings from a half to as much again as ordinary milk. Some of these dairies sent milk to the Paris Exposition without other treatment than cleanliness and a low temperature, and it arrived at its destination, strange as it may seem, sweet and in better condition than the milk from the local market only about as many hours old as the other was days old. Such dairies serve as models and object lessons to the dairy industry of the future. People are constantly demanding better and more cleanly methods of handling dairy products. And rightly, when we consider the number of cases of sickness and even death that results from carelessness on the part of the milk producer.

METHODS OF RAISING CREAM.

When milk is allowed to stand there is quickly formed a layer of fat globules and adherent particles of milk serum on its surface, and this layer is known as cream. Creaming of milk is practiced to obtain this great delicacy for our coffee, fruit and other toothsome dishes; but principally for the purpose of manufacturing butter. Whole milk can be and often is churned. But even though the separation of milk is always attended with some loss of fat, churning whole milk is much more wasteful. Whole milk is very bulky and therefore requires more frequent churnings. The higher churning temperature which it is necessary to use when churning whole milk means that the quality of the butter will not be as good and will not keep as well.

Some of our foreign brothers are said to churn by placing milk in a skin pouch and dragging it behind a horse. But even that method has its drawbacks.

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For many generations milk has been set in pans and crocks for cream to rise, and then the cream skimmed from the surface and churned. While good butter can be made in this way, especially when the work is done in a nice, cool spring house, yet this, like many of our farm operations, has been improved upon.

We have three general systems in use at present for raising cream, besides the dilution separators, a better name for which would be delusion separator. These patent devices for raising cream by the addition of water are simply money making schemes and are without value. They are separators in no true sense of the word any more than a "Cooley Can" is a separator.

THE SHALLOW PAN SYSTEM.

In the shallow pan system the fresh milk is strained into crocks or pans to the depth of three inches and kept at room temperature for thirty-six hours. This system has the disadvantage of exposing a large surface to the air, and unless the cream room is exceptionally free from dust the cream will become contaminated at this time. The cream is removed with a tin skimmer and placed in crocks and kept stored in some cool place until ready for churning. Besides the unsanitary side of this system, there are other serious objections to it. Both the skim milk and cream are sour at skimming time. It requires a lot of labor, time, and room to raise cream in this way. It often happens that as high as 18 per cent of the fat is lost in the skim milk. Many people would say that does not matter, since the hogs will get what we do not. While that is true we can not afford to feed our pigs on butter fat worth 20 to 25 cents a pound, when the same amount of fat can be purchased in the form of grain for a cent and a half or two cents.

If cool spring water is at hand the depth of the milk can be increased and better results be obtained by setting the crocks in water. The colder the water the better the results.

THE DEEP SETTING SYSTEM.

The deep setting system consists of increasing the depth of the milk to about 20 inches in cans of only eight or ten inches in diameter. The small diameter permits of the rapid cooling of the milk. These cans are then submerged in ice water. The best results can not be expected if the water is much above 40°. This system is seen at its best advantage in what is known as the Cooley System. The equipment necessary for using the Cooley System of raising cream is a tank for holding ice water and 18 quart cans, with two strips of glass soldered into the sides of the cans, one above the other, so that the position and amount of cream on the milk can be seen at a glance. A faucet in the bottom of the cans permits the skimmed milk to be

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removed without disturbing the cream layer. These Cooley tanks and cans for a herd of 25 cows cost about $50. A tank can be made on the farm which will be very satisfactory and much cheaper than one which can be bought. If you should be so fortunate as to have a good spring of cold water convenient a box can be lowered that will serve as a tank. The water should come up above the height of the milk in the cans, so that it will be necessary to have some way of fastening the cans in place. If small pieces are nailed on the sides of the tank with the lower edges on a level with the tops of the cans and thin strips like laths placed over the tops of the cans, the ends inserted under these strips, will hold the cans firmly in place even though they are only part full of milk.

The deep setting method of raising cream is much more thorough than the shallow pan system. The skim milk contains only about two-tenths of one per cent of fat. The cans, being completely submerged, reduces the chance of outside contamination during the creaming process. The cream rises quicker in the milk that is quickly cooled, requiring only about 24 hours for complete creaming. The cream and skim milk are both sweet at the end of the creaming period.

THE CENTRIFUGAL SYSTEM.

The slight difference in weight between skim milk and cream is sufficient to cause a separation when the whole milk enters a rapidly revolving bowl of a separator. If a stone is tied to a string and whirled about in the air the stone keeps pulling on the string. This force or tendency to fly off into space is known as centrifugal force. In the separator bowl, the skim milk being heavier than the cream, is thrown against the wall with greater force than the cream, and as the bowl fills the cream takes a place at or near the center, and is removed from the bowl through a small opening into the cream pan. Skim milk is removed through tubes that have their opening near the wall of the bowl furtherest from the center, where the skim milk contains the least fat, and flows into the skim milk pan. Thus in a few moments and in a much more thorough manner is accomplished what would require hours by the action of gravity alone. Each separator is equipped with a skim milk or cream screw, by which it is possible to regulate the quality of the cream. By changing the quality of the cream that runs from the separator, it should not materially change the amount of fat left in the skim milk. Practically all of the fat is removed from the skim milk. Regulating the cream screw varies the amount of skim milk that will be mixed with the fat.

The separator is much the most efficient way of raising cream. It is the most sanitary and in every way the most satisfactory. This method requires less labor; the cream is not only sweet, but of any

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quality desired, besides being in the best condition for butter making and commercial purposes. The skim milk not only contains the minimum amount of fat, but is sweet and in the best form for feeding purposes. About as much butter can be made from six cows and a separator as from seven cows and no separator.

It is to be hoped that the dairymen of North Carolina will not have to pass through all of the stages of development and experimenting that the dairymen of some of the older dairy States have traversed, but will recognize the great advantage to be gained by employing better methods and use of improved machines. This will enable North Carolina to step at once into the fore rank of dairy States, as her natural advantages and adaptability should entitle her to do. It rests with those who are engaged in this work to see to it that they profit by the experience of others. We can not afford the time or expense of following out the regular metamorphosis of the dairy business. We must read good agricultural books, papers and bulletins. We must think, study, and give our best efforts to our occupation.

RIPENING CREAM.

By ripening cream is generally meant the treatment of the cream after separating and before churning, and the cream is usually held at such temperatures and under such conditions as will bring about a souring of the cream.

It is necessary to treat cream in a little different manner, depending upon the method of separating. As stated above, the cream from the shallow pan is already sour when skimmed, and the cream from the deep setting system has already been subjected to a low temperature, which is essential to the production of the best butter.

Whenever two lots of cream of different ages are poured together they should be thoroughly mixed. Cream when allowed to stand ripens unevenly and tends to form a leathery top layer, therefore it should be stirred at least twice every day. Cream can be prevented from becoming over ripened by holding at a low temperature. Sweet cream should not be added to sour cream less than ten or twelve hours previous to churning. Otherwise the cream of different ages will churn in different lengths of time, and the result will be that the first to come will have to be churned too much or part of the other lot will be wasted in the butter milk.

Even when given special attention the ripening of cream by placing jar near the stove is very unsatisfactory to say nothing of the unsanitary side of the question. Cream very readily takes up any odor that happens to be present, and a place near the kitchen stove, of all places, is the most unsuited for that purpose.

Ripening cream can be very satisfactorily done by placing the

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cream jar in water and regulating the temperature of the cream by changing the temperature of the water. When running water is at hand for watering stock, many times it is possible to have the water first pass through a tank, over which a shelter or spring house can be erected at small cost and in which the cream can be kept at a low, even temperature even in the warmest weather. Such a tank need not be expensive, a good, stout box, especially if it is lowered into the ground, will answer for this purpose. The top of the cream should not be higher than the water level. If it is, there will be a layer of cream on top that will become over ripened. This may be overcome by nailing cleats on the inside of the box at just the right height so that when a lath is put across the top of a can and the ends under the cleats the can will be held firmly in place, though they be only part full of cream. Sometimes a good cold spring is conveniently located and by making use of a box as described above, it can be used for raising cream, cream ripening, and for holding the milk supply.

Cream as it comes from the separator should be cooled quickly to the ripening temperature. The lower this temperature, especially during warm weather, the better will the butter stand the effect of heat. If cream does not ripen fast enough add a little butter milk to the sweet cream when it is set away for ripening. Be sure that this starter has a good flavor. Otherwise the flavor of the butter will not be good.

It sometimes happens even in the best kept dairies that some trouble will creep in to cause bad fermentation in the cream or "off flavor" in the butter. If such trouble should occur, first try to overcome it, and it can nearly always be done by thoroughly scalding or steaming everything that comes in contact with the milk. If this fails, heat the cream to 149° F for thirty minutes, or 155° F for twenty minutes, and that will kill most of the germs that are likely to cause trouble. This is known as pasteurizing cream. Such cream, if kept protected from the air, will remain sweet for a long time, because the lactic acid germs that produce the acid and cause the souring have been destroyed, so that the cream should be inoculated either by the addition of some milk that is free from any trouble, or by the addition of some sour milk that has been soured by a germ that has been grown especially for this purpose. This is very much the same way in which a piece of land is treated for a crop. First the land is freed from all vegetation by plowing and sown with the kind of seed desired. We pasteurize the cream and destroy by heat the undesirable germs, and re-seed it with germs that are known to produce good results. This method of treating cream is of special importance in creameries where the cream and milk come from different sources and more or less beyond the control of the butter-

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maker. In small dairies there should be no trouble from bad fermentation, and will not be if cleanliness is the watchword.

CHURNING.

The fat in cream is not in solution but in minute globules floating in the watery portion, or milk serum as it is called. Churning consists of agitating the cream in such a manner that these particles of fat will unite. When they have assumed such a size as to be visible, the butter is said to "break." It was formerly supposed that each fat globule was incased in a thin membrane, and that churning was made possible by rupturing this covering.

The so-called troubles in churning can nearly always be overcome by bearing in mind what the churning process consists of, and the conditions that are likely to bring about a hard condition of the fat. If the temperature is below 50° the fat becomes so firm that continued churning fails to bring the butter. On the other hand, if the temperature is high the fat globules unite very quickly, and many times so quickly that the first together will either have to be churned too much or there will be a great many small fat globules left in the buttermilk. So that we have in the temperature one of the most important factors connected with churning. A difference of only a few degrees in churning temperature is sufficient not only to make a difference in the length of time required for churning but to determine very largely the quality of the butter. We are all familiar with the white, soft butter that has to be handled with a spoon during warm weather. It does not require an expert to tell under what conditions such cream was ripened and churned. You might as well try to sail without a rudder, as to try to make good butter without a thermometer. In one case the route would be about as direct as the other. A good dairy thermometer can be purchased from any dairy supply house for fifty cents, and the man who says that he can not afford to buy one admits that he is willing to let that sum stand between him and the profit to be made from good butter. People want good butter and are willing to pay for it. Poor butter is not wanted at any price.

CHURNS.

Churns with interior devices, such as floats and spiral wheels, are not to be recommended. They injure the grain of the butter. The most satisfactory churns are the box, barrel and swing type of churns. A good churn should fulfill the following requirements: It should have as few corners as possible, so that it can be easily cleaned. It should be easy to operate, and capable of bringing butter in a reasonable length of time. It should be so constructed that the butter milk and butter can be easily removed.

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Beware of those patent churns that require only three to five minutes for churning. The quick churning feature always appeals to the person who is in the habit of churning for several hours, and such churns find a very ready sale, greatly to the profit of the agents and manufacturers. The objection to these churns, and we have given them fair test, is their cost. Considering their churning capacity, the grain of the butter is not as good. An excessive amount of fat is left in the buttermilk, and the high temperature at which it is necessary to churn to secure rapid work does not improve the butter or its keeping qualities.

Butter can be churned in a reasonable length of time, provided only that conditions are as they should be. If the cream is ripened the same, and the temperature is right, there will be only a slight difference in the time required for churning from day to day. 58° in summer and 60° in winter make very good churning temperatures. The lowest temperature you can churn at and get the butter to come in 30 to 35 minutes the more butter can be made and the better will be its quality.

Never think of gaining time by churning within a few degrees of what the temperature should be. Either it will take a longer time to churn than would be consumed in regulating the temperature or you must be satisfied with less butter and be prepared to explain to your customers why the last butter they received from you was not as good as usual.

The temperature of cream can best be regulated or changed by placing the cream jar in water. Never pour water into the cream.

The difficulties experienced with churning will very largely if not entirely disappear if proper care is given to the points mentioned above. There has never been a lot of cream that could not be churned. Some foods, such as cotton-seed meal, tend to produce a hard fat, and when fed excessively may make it necessary to churn at a little higher temperature than when feeding some other kinds of grain. Cows nearing the end of their lactation period produce fat that does not churn as readily as when they are fresh. This is due to the size of the globules and to the change in the kind of fat.

WASHING BUTTER.

The churning should stop when the butter grains are quite small, about the size of kernels of wheat. This will permit a thorough removal of buttermilk by draining instead of trying to work it out after the butter has been gathered into large lumps. After the butter has been allowed to drain thoroughly it should be washed in at least two changes of water, and more if it is necessary, in order that the wash water may run away clear. Washing butter in large amounts of very cold water and allowing it to stand in ice water is objection-

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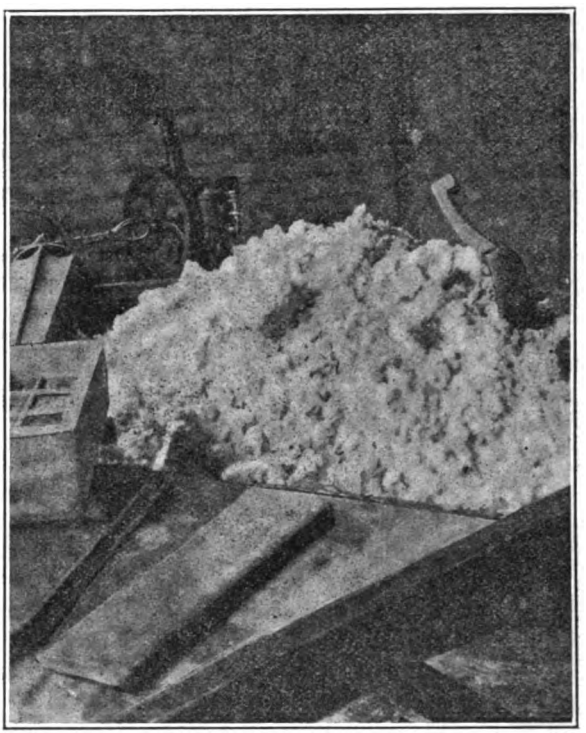
able, since it tends to remove some of the fine volatile flavors. The practice of churning at a high temperature and then cooling the butter by allowing it to stand in ice water not only tends to produce a tasteless butter, but butter that will not stand shipping. If the temperature of the work room is about the proper temperature for



BUTTER AS IT WAS TAKEN FROM THE CHURN, SHOWING GRANULATED CONDITION.

working butter (60°), the wash water should be the same. Otherwise it will be necessary to regulate the temperature of the water, so that the butter will not become either too firm or too soft during working and printing.

SALTING.

Salt is added to the butter principally for flavor as we use salt for seasoning other food, so that the amount to be used will depend very largely on the taste of the consumer. From ¾ to an ounce of salt to a pound of drained butter is the usual amount of salt used. The amount of water held by butter will be found to vary, depending upon the temperature, size of the butter grains, and the thoroughness

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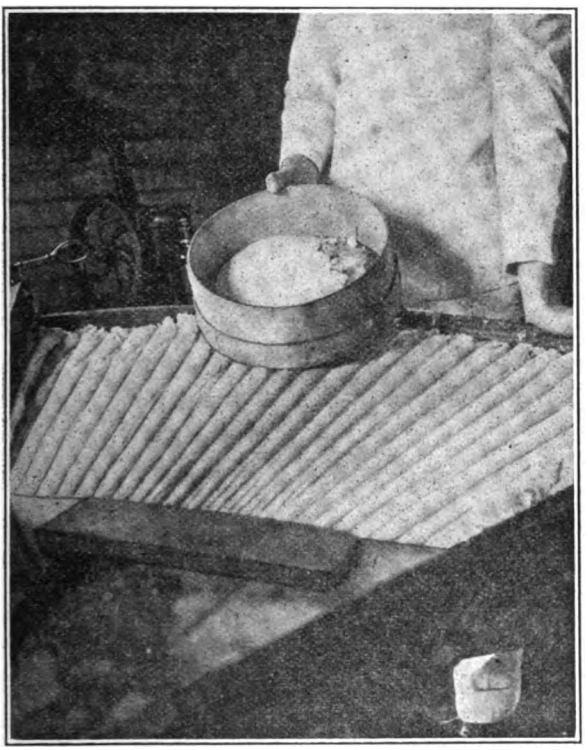
of draining. But the surplus salt added will be carried off during the working by the extra amount of water. So that very uniform results can be obtained this way even when the water content varies. Salt can also be incorporated by what is known as brine salting. After washing, or in place of the last washing, salt brine is added to



SALTING BUTTER ON A BUTTER-WORKER.

the butter in the churn and allowed to stand for fifteen minutes. The brine is then removed and a fresh lot added. Only a mild salting can be expected from this method.

WORKING.

The salt is usually mixed with the butter by a machine known as a butter worker, of which the market offers a great variety. For a hand worker the inclined table with a roller is the most satisfactory. The Skinner make is, we think, one of the best styles. except perhaps the Mason, which costs more money. For power the Mason worker is used more than any other style. In large dairies

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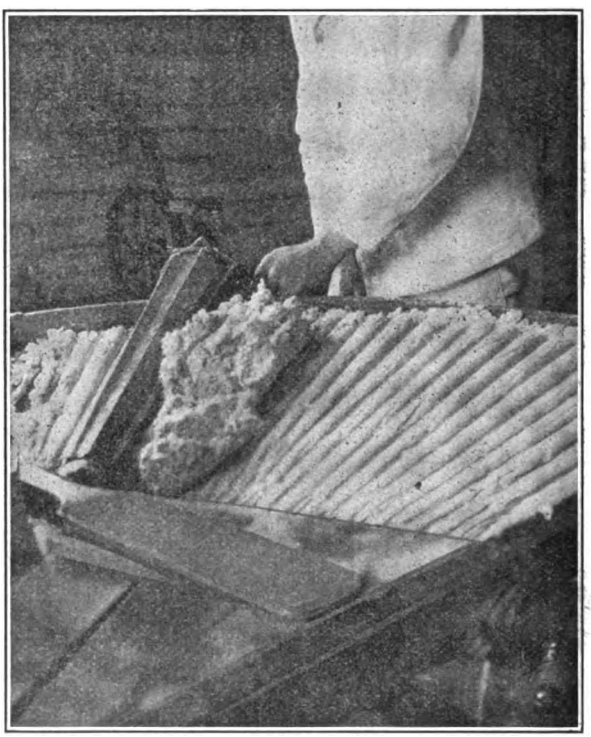
and creameries combined churns and butter workers are used. When only a small amount of butter is made on the farm, the salt can be added to the butter in the churn and worked by operating the churn.

Butter should be worked only enough to insure a uniform mixing of the salt with the butter. Beyond that working the butter tends to injure its texture. The butter, when ready for moulding, should be



SHOWS BUTTER-WORKER IN USE.

waxy in texture, and free from *salveyness*. When pulled apart it should show a granular condition. Pains should be taken to see that the salt is uniformly worked into the butter, otherwise the butter will have a mottled or streaked appearance. Except for the extra labor involved, twice working of the butter will be found to give more uniform and satisfactory results. The butter is worked only about half as much as usual and then set aside for a few hours until the salt is dissolved, and then worked a second time. The amount of working necessary will depend upon the use to be made of the butter. If it is to be packed or stored a more thorough working will be required. For immediate consumption a high moisture content is not objec-

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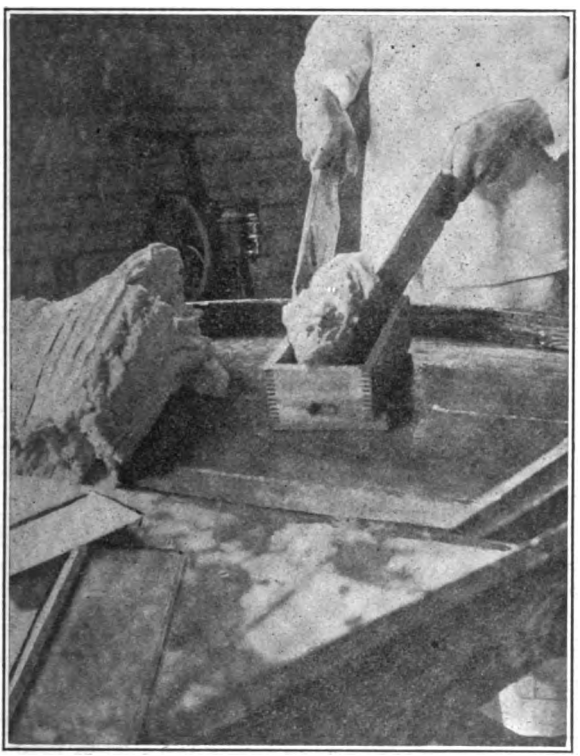
tionable, provided it is properly incorporated. The water should not stand on the surface in drops, for the salt deposited on the wrapper when it evaporates makes a bad looking package, and gives the consumer the impression that it has not been worked enough. Butter low in the per cent of moisture present, if it has not been



PRINTING BUTTER. HANDS SHOULD NOT TOUCH THE BUTTER

handled right, may give the impression of being insufficiently worked. In other words, the appearance of the butter is not always an indication of its moisture content; it more nearly represents the method of its manufacture.

PRINTING BUTTER.

After the butter has been worked into a compact form, it is customary to print or mould it into regular sizes and weights. The style of print used will depend on the demands of the market and the choice of the dairyman. The brick mould is considered the standard shape of print and is very convenient for shipping. Some prefer the round print, but it does not wrap up to make as nice a looking

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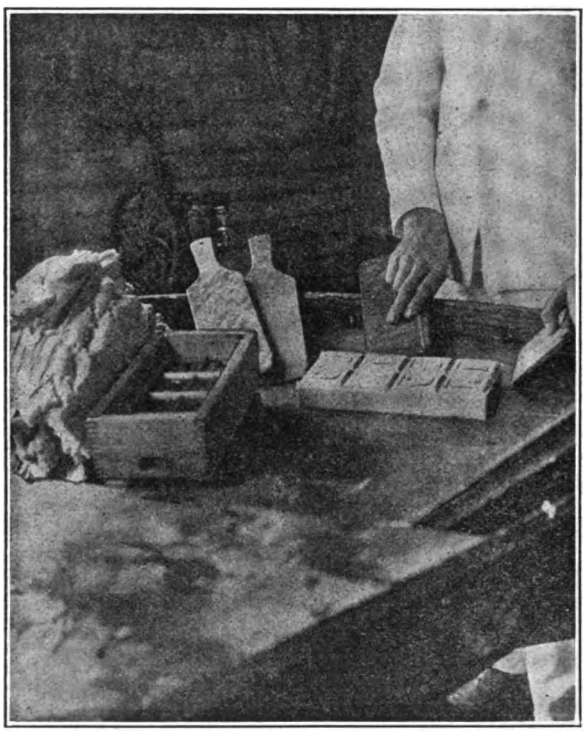
package and does not pack as well as the cakes with square corners. Another butter print that finds favor with many is what is known as the combination butter print. The small size print holds two pounds, and is marked off into eight squares of one-fourth pound capacity. The kind of butter mould to use does not make so much



FINISHED PRINT.

difference, provided it fulfills the requirements of a good print. The stamp should be neat, attractive, and bear some original design, such as name of dairy or design cut to represent the same. This is to serve as dairyman's trade-mark, and special care should be exercised to see that every block of butter having that mark comes up to the standard, and see that the standard be made high. There is pride as well as profit to be derived from the manufacture of good butter. Be sure that the butter mould gives good weight. Nothing will prejudice the purchaser quicker than scant weight.

The effect of an attractive mould is very largely lost unless the butter is properly wrapped in parchment paper, and is further protected and made more attractive if incased in one of the many wrap-

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pers especially constructed for holding butter for the fancy trade. It may seem expensive to carry out the ideas suggested above, but the cost of such coverings in quantity are very slight, and are more than offset by the higher price received for the butter so cared for. The least that the dairy man can afford to do is to wrap the butter in parchment paper, which only costs in small lots about fifty cents for a thousand sheets. The paper not only protects it from dust and odors, but permits easy and sanitary handling of the butter.

When butter is to be kept for some time on the farm, one of the best methods for keeping it in good condition is to pack it down firmly in stone jars. Salt should be sprinkled over the top of the butter, and on the sides and bottom of jar before butter is added.

If butter is to be shipped in large quantities without being moulded it should be packed in the regular size, sixty-pound five hoop tub. When the butter is to be sent to a distant market this style of tub should always be used. For nearby markets carrying cases for print butter are constructed both with and without ice compartments, so that butter can be shipped in fine condition even in warm weather.

MARKETING.

This brings us to the consideration of marketing butter and other dairy products. This is a subject that a great many of our dairymen need to consider. They are too easily discouraged over the difficulties found in shipping butter to better markets. Cream if properly cooled and cared for can be shipped hundreds of miles during warm weather, and there seems to be no limit to the distance that butter can be shipped. Far off countries, that were supposed to be entirely beyond the reach of our dairy markets, are now supplied with powdered milk and canned butter. We mention these things to illustrate the extent to which marketing of dairy products has been carried, and to impress upon our producers the necessity of finding the best market possible for their products. This is often the largest and most profitable end of the dairy business.

CHEESE MAKING.

While we have not the space to go into the details of the manufacture of cheese, this subject would be incomplete without touching upon the subject of farm cheese-making.

There is a great demand for cheese at high prices in this State, and all that is necessary to satisfy this demand is to produce good cheese uniform in quality. Very little cheese is made in this State and none on a commercial scale. Commission men tell us that cheese that for any reason does not find a ready sale on the Northern market is shipped South, and judging from the cheese usually found on sale we have no reason to doubt this statement. There are other

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things besides a good market and high prices to commend the making of cheese, to our dairymen. We have long seasons of warm weather, and in the manufacture of cheese we can do without ice to much better advantage than in other lines of dairying. Cheese can be more readily shipped and stored than butter, and will not so easily deteriorate.

Cheese is a most wholesome and nutritious food for home consumption, and every dairyman would do well to provide enough for this purpose, if not for sale. Cheese is worth in food value from as much to twice as much as equal amounts of meat.

We have in cheese-making in North Carolina a comparatively unexplored field. According to the last census report there were only 192 farms in the State that reported its manufacture, and from the total amount of cheese made we judge that the output from each farm must have been very small.

EQUIPMENT FOR A DAIRY OF TWENTY COWS.

1 Separator, capacity 500 pounds per hour.
1 No. 4 Stoddard Barrel Churn, or 1 No. 4 Davis Swing Churn.
1 No. 4 Skinner Butter Worker.
4 14-quart dairy pails.
2 10-inch hair sieves.
1 300-pound Platform Dairy Scales.
2 Butter bowls.
1 8-Bottle Babcock Tester.
2 Dairy Thermometers.
1 Rubber floor mat.
2 Factory brooms.
1 Butter mould.
2 Boxes of butter paper.
Assortment of butter ladles and spades.
Assortment of scrub brushes.
Washing powder.
Salt.

The above equipment should be bought and installed for less than $200.00.

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TWENTY-NINTH ANNUAL REPORT

OF THE

NORTH CAROLINA

Agricultural Experiment Station

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

FOR THE

Year Ending June 30, 1906.

INCLUDING BULLETINS Nos. 193, 194.

Raleigh, North Carolina.

RALEIGH:
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1907.

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N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

S. L. PATTERSON, *ex officio* Chairman, Raleigh.

J. M. FOREHAND ..... Tyner	A. T MCCALLUM ..... Red Springs
J. B. STOKES ..... Windsor	J. P. MCRAE ..... Laurinburg
WM. DUNN ..... New Bern	R. L DOUGHTON ..... Laurel Springs
C. N. ALLEN ..... Auburn	W. A GRAHAM ..... Machpelah.
R. W. SCOTT ..... Melville	A. CANNON ..... Horse Shoe

STATION STAFF.

GEO. T. WINSTON, LL. D., President of the College.

B. W. KILGORE ..... Director.
W. A. WITHERS ..... Chemist.
C. W. BURKETT ..... Agriculturist.
TAIT BUTLER ..... Veterinarian.
F. L. STEVENS ..... Biologist.
H. H HUME ..... Horticulturist.
J. S. JEFFREY ..... Poultryman.
R. S. WOGLUM ..... Acting Entomologist.
WILLIAM KERR ..... Assistant in Field Experiments.
J. C. KENDALL ..... Assistant Dairy Husbandry.
O. L. BAGLEY ..... Assistant Chemist.
R. H. HARPER ..... Assistant Chemist.
F. C. REIMER ..... Assistant Horticulturist.
A. F. BOWEN ..... Bursar.

The Director's office is in the Agricultural Building, Raleigh; the experiment grounds and laboratories being at the Agricultural College just west of town and on the street car line.

Visitors will be welcome at all times and will be given every opportunity to inspect the work of the Station. Bulletins and reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

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Number 194, Mulberries.

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LETTER OF TRANSMITTAL.

RALEIGH, N. C., June 30, 1906.

To His Excellency, ROBERT B. GLENN,

Governor of North Carolina:

SIR:—I have the honor to transmit herewith the report of the operations of the Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts, for the year beginning July 1, 1905, and ending June 30, 1906.

Very respectfully,

S. L. PATTERSON,
Chairman Board of Trustees.

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LETTER OF SUBMITTAL.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,
OFFICE OF THE DIRECTOR,
RALEIGH, N. C., June 30, 1906.

HON. S. L. PATTERSON, *Chairman Board of Trustees.*

SIR:—I have the honor to transmit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts, for the year ending June 30, 1906.

Trusting that this report will prove satisfactory, I am,

Very respectfully,

B. W. KILGORE,
Director.

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TWENTY-NINTH ANNUAL REPORT

OF THE DIRECTOR OF THE

N. C. AGRICULTURAL EXPERIMENT STATION

For the Year Ending June 30, 1906.

BY THE DIRECTOR.

This report covers the work of the Station from July 1, 1905, to June 30, 1906.

THE ADAMS FUND.

An Act was passed by the Congress of the United States and approved by the President on March 16, 1906, known as the Adams Act, and is entitled "An Act to Provide for an Increased Annual Appropriation for Agricultural Experiment Stations and Regulating the Expenditure Thereof." The amount of this appropriation was five thousand dollars for 1906, which is to increase two thousand dollars annually until a total of fifteen thousand dollars is reached, which will give, under the two experiment station acts of Congress, namely, the Hatch and Adams Acts, a total of thirty thousand dollars for use in conducting agricultural experiment stations in the several states and territories. This Act is as follows:

ADAMS ACT.

"An Act to provide for an increased annual appropriation for agricultural experiment stations and regulating the expenditure thereof.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there shall be, and hereby is, annually appropriated, out of any money in the Treasury not otherwise appropriated, to be paid as hereinafter provided, to each State and territory for the more complete endowment and maintenance of agricultural experiment stations now established or which may hereafter be established in accordance with the act of Congress approved March second, eighteen hundred and eighty-seven, the sum of five thousand dollars, in addition to the sum named in said act for the year ending June thirtieth, nineteen hundred and six, and an annual increase of the amount of such appropriation thereafter for five years by an additional sum of two thousand dollars over the preceding year, and the annual amount to be paid thereafter to each State and territory shall be thirty thousand dollars, to be applied only to paying the necessary expenses of conducting original researches or experiments bearing directly on the agricultural industry of the United States, having due regard to the varying conditions and needs of the respective States or territories.

Sec. 2. That the sums hereby appropriated to the States and territories for the further endowment and support of agricultural experiment stations shall be annually paid in equal quarterly payments on the first day of January, April, July and October of each year by the Secretary of the Treasury, upon the warrant of the Secretary of Agriculture, out of the Treasury of the United States, to the treasurer or other officer duly appointed by the governing boards of said experiment stations to receive the same, and such officers shall be required to report to the Secretary of Agriculture on or before the first day of September of each year, a detailed statement of the amount so received and of its disbursement on

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schedules prescribed by the Secretary of Agriculture. The grants of money authorized by this act are made subject to legislative assent of the several States and territories to the purpose of said grants. *Provided*, that payment of such installments of the appropriation herein made as shall become due to any State or territory before the adjournment of the regular session of Legislature meeting next after the passage of this act shall be made upon the assent of the Governor thereof, duly certified by the Secretary of the Treasury.

Sec. 3. That if any portion of the moneys received by the designated officer of any State or territory for the further and more complete endowment, support and maintenance of agricultural experiment stations as provided in this act shall by any action or contingency be diminished or lost or be misapplied, it shall be replaced by said State or territory to which it belongs, and until so replaced no subsequent appropriation shall be apportioned or paid to such State or territory; and no portion of said moneys exceeding five per centum of each annual appropriation shall be applied, directly or indirectly, under any pretense whatever, to the purchase, erection, preservation, or repair of any building or buildings, or to the purchase or rental of land. It shall be the duty of each of said stations annually, on or before the first day of February, to make to the Governor of the State or territory in which it is located a full and detailed report of its operations, including a statement of receipts and expenditures, a copy of which report shall be sent to each of said stations, to the Secretary of Agriculture, and to the Secretary of the treasury of the United States.

Sec. 4. That on or before the first day of July in each year after the passage of this act the Secretary of Agriculture shall ascertain and certify to the Secretary of the Treasury as to each State and territory whether it is complying with the provisions of this act and is entitled to receive its share of the annual appropriation for agricultural experiment stations under this act and the amount which thereupon each is entitled, respectively, to receive. If the Secretary of Agriculture shall withhold a certificate from any State or territory of its appropriation, the facts and reasons therefor shall be reported to the President and the amount involved shall be kept separate in the Treasury until the close of the next Congress in order that the State or territory may, if it shall so desire, appeal to Congress from the determination of the Secretary of Agriculture. If the next Congress shall not direct such sum to be paid it shall be covered into the Treasury; and the Secretary of Agriculture is hereby charged with the proper administration of this law.

Sec. 5. That the Secretary of Agriculture shall make an annual report to Congress on the receipts and expenditures and work of the agricultural experiment stations in all of the States and territories, and also whether the appropriation of any State or territory has been withheld, and if so, the reason therefor.

Sec. 6. That Congress may at any time amend, suspend or repeal any or all of the provisions of this act.

Approved, March 16, 1906.

The Secretary of Agriculture is charged with the administration of this law, which provides that the funds are "to be applied only to paying the necessary expenses of conducting original researches or experiments bearing directly on the agricultural industry of the United States."

The policy of the Secretary of Agriculture with reference to the administration of the Act is outlined in the following letter:

"UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
WASHINGTON, D. C., March 20, 1906.

To the Directors of the Agricultural Experiment Stations.

Congress having passed the Adams Bill, which provides for an increased annual appropriation for agricultural experiment stations, and the measure having been

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approved by the President, it becomes my duty to undertake the administration of this law.

In order to facilitate the prompt and effective organization of work under this act, and to provide for a proper accounting for expenditures authorized by said act, I have prescribed a schedule for the report of such expenditures for the fiscal year ending June 30, 1906, and until further orders, in accordance with section 2 of said act. Copies of this schedule will be sent later.

The Director of the Office of Experiment Stations is hereby designated my representative in all matters relating to the business of this Department in connection with the administration of this law, and the Office of Experiment Stations will aid in promoting effective work under this act in the same general way as it has heretofore in relation to the Hatch Act.

Under the terms of the act it will be necessary that a separate account of the Adams fund shall be kept at each station, which should be open at all times to the inspection of the Director of the Office of Experiment Stations, or his accredited representative.

In the interpretation of this act and the examination of the work and expenditures of the stations under it, I have instructed the Director of the Office of Experiment Stations to be guided by the following principles:

The Adams fund is 'to be applied only to paying the necessary expenses of conducting original researches or experiments bearing directly on the agricultural industry of the United States.' It is for the 'more complete endowment and maintenance' of the experiment stations, presupposing the provision of a working plant and administrative officers. Accordingly, expenses for administration, care of buildings and grounds, insurance, office furniture and fittings, general maintenance of the station farm and animals, verification and demonstration experiments, compilations, farmers' institute work, traveling, except as is immediately connected with original researches in progress under this act, and other general expenses for the maintenance of the experiment stations, are not to be charged to this fund. The act makes no provision for printing or for the distribution of publications, which should be charged to other funds.

In order that there may be no doubt as to the disposal of the Adams fund, each station should outline a definite programme of experimental work to which it will devote this fund, and expenses for other work should not be charged to it. The work contemplated by this act will, as a rule, necessarily cover more than one year, and changes in the programme once adopted should not be made until the problems under investigation have been solved, or their solution definitely shown to be impracticable. This will give ample opportunity for making plans for winding up any particular piece of work and beginning another with such deliberation as will provide for the suitable and economical expenditure of this fund without resort to doubtful expedients or expenditures. It is much to be desired that this fund shall be a strong incentive to the careful choice of problems to be investigated, thorough and exhaustive work in their solution, and the securing of permanent and far-reaching results on which can be safely based demonstration and verification experiments leading to the general improvement of farm practice in many particulars.

No change will be made in the attitude of this Department toward expenditures under the Hatch Act. The Hatch fund should be as carefully guarded as ever, and be devoted to substantial experimental work and the printing and dissemination of the results of such work.

The increased liberality of the Federal government in providing for the endowment of research and experimentation in agriculture should be a further incentive to the States and local communities to supplement these funds for the extension of demonstration experiments, farmers' institutes, agricultural colleges, schools, and courses of instruction, and the general education of the rural communities along industrial lines, in order that the masses of our farmers may be so educated from early youth that they will appreciate the benefits of original research and experimentation as applied to agricultural problems, and be able to appropriate in the most effective manner for their own benefit and the general welfare of the nation whatever practical results are obtained from the work of the agricultural experiment stations.

Very truly yours,

JAMES WILSON,
Secretary."

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CHANGES IN STATION STAFF.

Prof. W. F. Massey, who has been long connected with the Station as Horticulturist, resigned in December to devote his entire time and energies to editorial work. His place was filled by the election of Prof. H. H. Hume; Mr. F. C. Reimer was added to the staff as assistant horticulturist. Dr. Charles Walker was transferred from the Station to the College, and his work has been done by Messrs. R. H. Harper and O. L. Bagley.

WORK IN THE AGRICULTURAL DIVISION.

The experiments which have been in operation for the past four years with cotton and corn in testing varieties, fertilizer requirements, and culture methods, have been continued in order to obtain further data on these subjects. Similar experiments are in progress with cow peas and soja beans.

A considerable number of plats have been devoted to alfalfa, with a view of determining the best time, methods and amount of seeding, inoculation, fertilization, etc.

Plat experiments with grasses and other forage crops are also being continued, in order to collect further data regarding the production of these crops. Some work has been done in dairying and the feeding experiments with horses and mules with our home-grown feeds have been continued.

WORK IN THE CHEMICAL DIVISION.

The Chemical Division has continued its study of nitrogenous fertilizer materials, their changes in soil through the agency of bacteria, and the effect of various changes on the distribution and growth of soil bacteria affecting nitrogen-furnishing materials. It has also been necessary to study methods in connection with these various lines of work.

WORK IN THE BIOLOGICAL DIVISION.

In the work of the Biological Division in the study of plant diseases and methods of combatting these, tests have been continued at Auburn by the Station in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture, with the view of developing a variety of watermelon which will resist the watermelon wilt. The present results are encouraging.

The Granville tobacco wilt work is also being continued, the tests including a large number of varieties, together with the study of possible methods of overcoming the disease.

In like manner a large number of varieties of sweet potatoes are being grown in Perquimans County, in the hope of getting a variety which will withstand the wilt disease which is affecting this crop.

Several co-operative spraying experiments are being made in dif-

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ferent parts of the trucking belt on cucumbers, Irish potatoes, cantaloupes, tomatoes and similar crops, for the purpose of testing methods of preventing or reducing damages to these crops by various fungous diseases.

WORK IN THE VETERINARY DIVISION.

The State Department of Agriculture furnishes the main support to the veterinary work, the Station only paying a part of the salary of the Veterinarian.

In addition to dealing with the various diseases of domestic animals and giving general encouragement to the live stock interests of the State, the Veterinarian has devoted special efforts to the development of methods for the extermination of the cattle fever tick. In 1902 only sixteen of the western counties of the State were exempt from the Federal cattle quarantine restrictions. At the close of 1906 thirty-six counties have been practically freed from this pest. This shows that decided progress has been made in this work. With the aid of the National Government the eradication of the tick in the State in the future should be and will be more rapid.

WORK IN THE POULTRY DIVISION.

One additional building was added to the poultry plant during the past year for use in keeping male birds when not in use in the breeding season. The quality and healthfulness of the stock is greatly improved, as has general interest in poultry production in the State. This is shown by the increase in correspondence and interest at Farmers' Institutes which the Poultryman has attended.

Experiments are being conducted in pedigreed breeding for egg production; dry feeding from hoppers in comparison with mash feeding for laying hens; hopper feeding for brooder-raised chicks; test of the value of green feed in winter, both as to the number of eggs laid and the percentage of fertility; and the number of chicks hatched in comparison of different methods of cooling and turning eggs in incubator; and increase of egg production from different breeds.

WORK IN THE ENTOMOLOGICAL DIVISION.

With the exception of a part of the salary of the Entomologist the entomological work is provided for by the State Department of Agriculture. During the past year the main efforts have been directed toward methods for the eradication and control of the San Jose' scale, testing of comparative means of combatting the curculio of the peach, and some investigations as to the present conditions of bee-keeping and bee culture, with the view of inaugurating some experiments in this line.

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PUBLICATIONS.

Bulletins have been issued as follows:

No. 193—Spraying Mixtures and Machinery, by F. L. Stevens and R. S. Woglum.

No. 194—Mulberries, by H. H. Hume and F. C. Reimer.

The reports of the heads of the several divisions of the Station and financial statement follow:

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REPORT OF THE AGRICULTURAL DIVISION.

PROF. B. W. KILGORE, *Director.*

DEAR SIR:—The work of the Agricultural Division, during the past year, has been along similar lines as outlined in previous reports. The major part of this work is grouped under Plat Experiments that include the important phases of field work in the State. In planning these experiments the aim has been to study fundamental principles rather than immediate results. The following field crops are included in this division of the work:

(1) *Corn.*—Several phases of corn production are being studied, including fertilization, rotations of various crops in relation to corn production, varieties of corn best suited to State conditions, methods of culture and selection of seed. This work has been in progress for the past four years and is designed to cover an extended period that definite conclusions may be drawn. It will follow that additional plats will be necessary for this work as the results now indicate.

(2) *Cotton experiments.*—Involving a study of fertilization, rotations in relation to cotton production, varieties of cotton, methods of culture, etc., are included in the plat work devoted to this important field crop. Like corn these tests have been conducted for a period of four years and should be the beginning of a series of more extended tests.

(3) *Cow Peas.*—Included in this study are varieties, time of planting, fertilization and methods of culture. This work now covering a period of four years is to be continued.

(4) *Soja Beans.*—Similar tests as outlined for cow peas are being conducted with this crop.

(5) *Alfalfa.*—Sixty field plats have been used in the tests with alfalfa where methods of seeding, methods of inoculation and fertilization are studied. Twenty additional plats have been used for this work during the past year and the importance of the work from results already secured indicate that a more extended study should be given this subject.

(8) *Forage Crops and Grasses.*—The leading and important forage crops of the country have received attention by this division during the past five years. The object has been to ascertain times best suited to State conditions. This work should be continued indefinitely that every phase may be carefully studied.

DAIRY PRACTICE.

Dairying is assuming larger proportions than formerly in this State, consequently this division of the Station is giving such attention as possible to its needs. The Station work includes:

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(a) Comparison of available feeding stuffs.
(b) Productive capacity of individual cows.
(c) External form as an index of dairy quality.
(d) Cost of producing milk, cream and butter under State conditions.
(e) Best means of building up dairy herds.

Other lines of dairy work, particularly along lines of dairy manufacture, are being outlined for subsequent work for the coming year.

HORSES AND MULES.

The feeding of horses and mules with home-raised feeding stuffs is being continued. College teams are used for this purpose. The object in these tests is to study the efficiency of home-grown feeds and to study the effect upon work produced.

Very truly yours,

C. W. BURKETT,
Agriculturist.

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REPORT OF THE CHEMICAL DIVISION.

PROF. B. W. KILGORE, *Director.*

DEAR SIR:—During the past year ended June 30 the Chemical Division continued its study of the changes which took place in nitrogen, when added to the soil in different forms of combination. Some of the more important results are:

1. *Modification of form in which nitrogen was added.*—Heretofore the two nitrogenous materials supplied to the soil were ammonium sulphate and cottonseed meal, two substances fairly representative of the usual inorganic and organic nitrogenous fertilizers. During the past year asparagin was substituted for cottonseed meal for three reasons: (a) because with cottonseed meal containing phosphoric acid and potash which furnish food for the nitrifying organisms and unless correction is made for the effect of these elements, the results with other nitrogenous material are not comparative; (b) because the nitrogenous material in cottonseed meal is not a definite chemical compound, and (c) because asparagin is a definite chemical compound, not very difficult to obtain in a pure form and not subject to change when kept stored. In addition to asparagin and ammonium sulphate, the salts sodium nitrite and sodium nitrate were used, and in consequence the four nitrogenous materials supplied amide and amine nitrogen, ammoniacal nitrogen, nitrite nitrogen and nitrate nitrogen. It will probably be desirable in the near future to use also some of the albuminoids.

2. *Forms of nitrogen in the product.*—Heretofore only nitrates and nitrites were determined in the product. In addition to these the determinations of organic and ammoniacal nitrogen in the product have been made.

3. *Completeness of extraction by water and shaking.*—Samples of the soil used in the other work were sterilized and treated with different nitrogenous materials, immediately shaken in a shaking machine for four hours with the usual amount of water, filtered in the usual manner and the amount of nitrogen in the filtrate determined. It was found that the percentages given below were recovered in the filtrate:

Asparagin	88.60 per cent.
Ammonium sulphate	88.18 per cent.
Sodium nitrite	59.44 per cent.
Sodium nitrate	91.90 per cent.

This shows very good recovery in every case but nitrites.

4. *Source of inaccuracy in the Tiemann-Schulze method for determining nitrates and nitrites.*—It has been noted previously that the gas evolved by this method, which is supposed to be nitrogen dioxide, is not entirely soluble in a solution of ferrous sulphate,

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there being amounts of residual gas varying from practically nothing to as much as five cubic centimeters. The method was carried through, omitting the addition of a nitrogenous compound and using simply distilled water, hydrochloric acid, or ferrous chloride, then two of these substances and then all three. At the end of the operation water, heated almost to the boiling point, was introduced to the flask and the gas washed out into an eudiometer. The amount of this gas was found to vary just as when the nitrogenous material had been added, showing that the gas was not liberated from the nitrogenous material, but consisted of air, which had leaked into the apparatus or which had been dissolved in one of the liquids introduced to the flask.

5. *Determination of nitrites.*—The method heretofore used by the this Division and the method of the Bureau of Soils were tested with solutions of known strength and found to be equally accurate, but as the final color produced by the Bureau method is pink instead of yellow it is more easily read and is probably more accurate with soil solutions which are slightly yellow. It has accordingly been substituted this year.

6. *Decolorization of solution.*—As the method of determining nitrites is colorimetric, it is necessary to clarify this solution. The Bureau of Soils uses pure carbon black for this purpose. This Division did not have any of this substance on hand, could obtain none from New York and there was not sufficient time for it to be imported. The results with lampblack, animal charcoal, ammonia, sodium carbonate and alum, each of which has been proposed, were compared. Lampblack, with the oil extracted by alcohol or gasoline, was satisfactory as was also the treatment with ammonia and alum together, there being an excess of alum. Both of these methods were tried with solutions of known strength. The treatment with the lampblack gave the most satisfactory results because it did not alter the volume of the solution. By allowing the solution to stand for awhile without other treatment a large part of the coloring matter settles out.

7. *Effect of time and season upon nitrifying organisms.*—In March, 1905, some samples of soil from Mr. Sloan's garden were placed in battery jars upon the roof and exposed to atmospheric conditions. Grass grew luxuriantly. When originally taken these samples had good nitrifying powers. The following results were obtained after some month's standing:

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Nitrogenous Material Added.	Nitrites Formed.		Nitrates Formed.	
	Sept. 1905.	Feb. 1906.	Sept 1905	Feb. 1906.
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*
Blank	None	None.	2.20	None.
Asparagin	23.77	None.	4.21	None.
Ammonium sulphate	Trace.	None.	21.95	None.
Sodium nitrite	Omitted.	2.23	Omitted.	None.
Sodium nitrate	Omitted.	None.	Omitted.	45.58

This soil with or without added nitrogen produced no nitrates nor nitrites in February. As the amount of nitrogen which was recovered was considerably less than that added, there was evidently some change toward reduction, as nitrites and nitrates were formed in September and not in February following it would indicate that the organisms producing these changes were injured by the cold, compactness of the soil or the growth of grass.

8. *New organism.*—It is a matter of interest that in September this soil produced nitrites, but no nitrates from asparagin, and nitrates, but no nitrites from ammonium sulphate. This would confirm conclusions heretofore reached by the Division that the oxidation of organic nitrogen and of ammoniacal nitrogen is accomplished by different organisms. These results suggest the desirability of further work along this line.

9. *Rapidity of natural inoculation.*—A sample of soil from Mr. Sloan's garden was sterilized and placed upon the roof near the samples from the same garden which had not been sterilized. In January, 1906, a sample was taken, various nitrogenous materials were added and after standing for four weeks nitrites and nitrates were determined with the following results:

Nitrogenous Material Added.	Nitrites	Nitrates.
	Per Cent	*Per Cent.*
Blank	None.	None
Asparagin	16.84	None.
Ammonium sulphate	15.55	1.78
Sodium nitrite	41.28	None.
Sodium nitrate	6.74	76.66

This shows that the nitrogen-oxidizing organisms are readily transferred from one soil to another. It is desirable to test this point further by making determinations at brief intervals and by placing the sterilized samples at a greater distance from the inoculating soil.

10. *Sensibility of organisms.*—The results noted above show that the nitrate-forming organism which was in the soil in September did not appear to be present in February in the natural or in the previ-

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ously sterilized soil. As a smaller part of the nitrogen is recovered in the winter in the form of nitrites from the soil containing grass than from the previously sterilized soil, it would indicate that the nitrite-forming organism while more resistant than the nitrate-forming, is less resistant than the reducing organism.

11. *The adaptability of one soil for bacteria of another.* The soil. from the experimental plats produced no nitrates nor nitrites from asparagin or ammonium sulphate, when previously sterilized and inoculated with soil from Mr. Park's garden.

12. *Effect upon nitrifying power of previous treatment with solvents and previous ignition.* This was tried with soil from the experimental plats inoculated with soil from Mr. Park's garden, but as the soil itself gave no nitrifation, the results were negative of course. It was not anticipated that the natural soil would give negative results, as it was fairly productive. The solvents used were fifth, fiftieth and two hundredth normal hydrochloric acid. The acid was washed out with water as completely as possible and any remaining acidity overcome by the addition of a solution of calcium acid carbonate. This will be continued with other soils.

13. *Effect of the addition of various fertilizing materials to the soil upon its nitrifying power.*—The materials used were sodium hydrogen phosphate, potassium sulphate and calcium carbonate singly and in combination. This series is in progress.

FUTURE WORK.

During the coming year we wish to follow up some of the points suggested above under the different headings, studying different soils to ascertain the food best suited to each soil, the effect of various solvents upon plant food, the rapidity of natural inoculation and the adaptability of one soil for the growth of the organisms of another.

The work of this Division in the past has indicated that the soil contains an organism capable of oxidizing organic nitrogen without previously passing through the form of ammonia. It is desirable to separate this organism if in existence, and for this purpose I would respectfully recommend the appointment of Mr. J. C. Temple, a recent graduate in agriculture from this college, who has been pursuing advanced studies during the past year in chemistry and bacteriology.

Mr. Harper and Mr. Bagley wish to sever their connection with the Station, much to my regret. They have both been satisfactory workers. I would respectfully recommend the appointment of Dr. Wm. A. Syme, an alumnus of this college, who has just completed his postgraduate studies at the Johns Hopkins University.

Nitrogen is the most expensive element which the farmer purchases and the element susceptible of the most changes. It is to be hoped that our results will continue to throw light upon some of the changes which take place in its combinations and upon some of the conditions under which these changes take place in the soil.

Very respectfully, W. A. WITHERS, *Chemist.*

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REPORT OF THE BIOLOGICAL DIVISION.

MR. B. W. KILGORE, *Director.*

DEAR SIR:—I beg leave to submit a report of investigations of the fiscal year now closing:

Watermelon Wilt.—Co-operative work with the National Department of Agriculture has been continued at Auburn in the attempt to secure a variety of watermelon resistant to the watermelon wilt. Twenty hybrids were tested last year. Among these resistant varieties were many individuals which possessed, in addition to resistance, high commercial value. They were sweet, crisp, firm, solid, fine grained, with thin hard rind; in every way of the highest rank. Such edible melons possessing resistance were much more numerous this year than last, and it is hoped that succeeding years may lead to the fixation of some of these types so that they will come true to seed.

Truck Diseases.—In April a trip through the trucking region was made for the purpose of ascertaining what plant diseases were most destructive and to plan experiments looking to their control. The following co-operative experiments were arranged for. At LaGrange, experiments concerning spraying *Irish potatoes* to determine the value of spraying with the ordinary Bordeaux and the soda Bordeaux in comparison with no spraying at all. Also at LaGrange a similar experiment with *cucumbers.* At Newbern a similar experiment with *cucumbers.* At Mt. Olive a similar experiment with *cantaloupes.* At Rocky Point a similar experience with *cucumbers.* At Wilmington similar experiments with *Irish potatoes, cucumbers* and *tomatoes.* At Maxton similar experiments with *beans* and *cantaloupes.* At Fayetteville similar experiments with *Irish potatoes.* In all cases the crops mentioned suffer seriously by injury from fungi, and the experience in other States has been that the specific diseases here mentioned can be controlled by means which we are testing. It is hoped that these experiments may serve as object lessons as well as tests of efficiency of the remedy under conditions prevailing in North Carolina.

Tabacco Wilt.—Experiments have been continued at Creedmoor in testing different varieties of tobacco as regards their power to resist the Granville Tobacco Wilt. No variety has yet been found possessing resistance enough to warrant selection from it. A large number of new varieties, including varieties from Cuba, Brazil, Persia, China, and Japan are at hand and will be tested this year.

A canvass of the farm conditions in Granville County was made with the hope of throwing light upon the relation of this disease to crop rotation, soil, fertilizers, water, etc. Observations were made which will be the basis of future work.

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Sweet Potato Wilt.—This disease destroys more than half the crop on farms in many portions of the State. All the varieties of sweet potatoes known, about twenty-seven in all, will be grown on affected soil in Perquimans County, with the hope of finding some variety more resistant to this disease than the varieties ordinarily grown.

Correspondence.—A large correspondence, chiefly concerning plant diseases has beem conducted, and timely articles concerning plant diseases and their treatment have been prepared for local newspapers and agricultural papers.

Nature Study.—In every way possible efforts have been made to sustain and increase the interest of the teachers of the State in Nature Study. These efforts have consisted chiefly in writing articles for publication; in writing letters to the teachers of the State; and a bulletin for the State Department of Education.

Co-operative work on Plant Disease Survey.—In co-operation with the National Department of Agriculture an attempt has been made to secure by correspondence information, data, statistics, and specimens concerning the plant diseases of the State.

Student Investigation.—Under the guidance of the Station Botanist and Plant Pathologist, one of the students of the College has spent much time in investigating the bacteriology of manure, the number of bacteria, the kinds of bacteria, and their relation to its nitrogen content.

Respectfully submitted,

F. L. STEVENS,

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REPORT OF THE VETERINARY DIVISION.

MR. B. W. KILGORE, *Director.*

DEAR SIR:—The following report is respectfully submitted from the Veterinary Division:

Since my last report this Division has continued its experimental work in methods of tick (Boophilus annulatus) eradication. The results obtained and previously reported have attracted the attention of live stock sanitarians throughout the whole tick infested area of this country, and recognizing that no question involving the live stock interests of the South approaches in importance the eradication of the cattle fever tick, Congress has made an appropriation to enable the Federal Bureau of Animal Industry to co-operate with the several tick infested States in inaugurating this work, which is to eventually remove from the cattle industry of the South the most serious obstacle to its development. It is not immodest to state that this national interest and activity in the work of tick eradication is largely due to the successful pioneer work done in North Carolina.

Our work during the past year has served to confirm the opinion previously reported that the complete eradication of the cattle fever tick is entirely practicable in any given area or territory where the cattle can be controlled or where the "stock law" or "no fence law" is enforced. Not only is this true, but such eradication may be accomplished at a cost well within the loss occasioned by the presence of the ticks for the short period of one or two years.

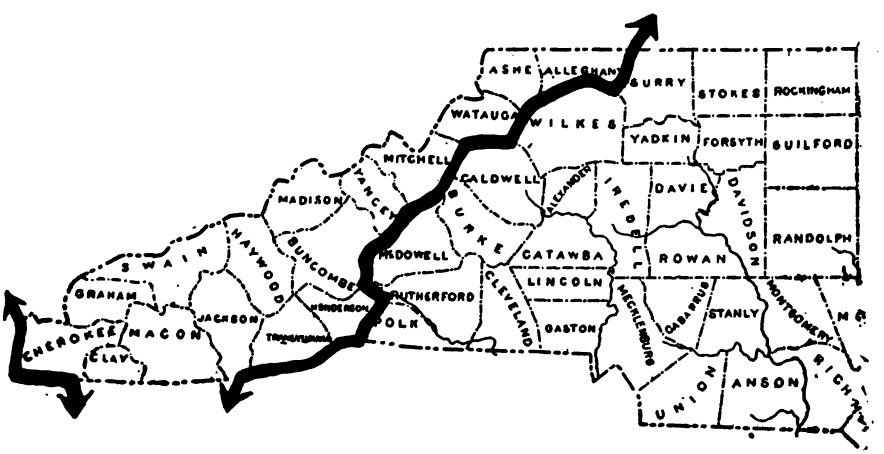

Fig. 1.—Tick Fever Cattle Quarantine Line across North Carolina, 1902.

In 1902 only sixteen of the Western Counties of the State were free from the Federal cattle quarantine restriction (See Fig. 1, page

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21). At the close of work for the season of 1906 thirty-six counties are ready for exemption and will be released during 1907 (See Fig. 2,

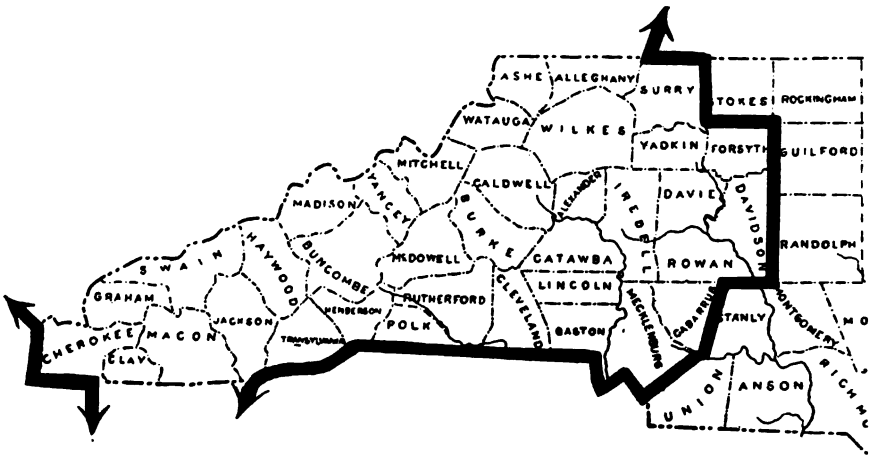

Fig. 2.—Tick Fever Cattle Quarantine Line across North Carolina, 1907.

The twenty counties which have been released from Federal quarantine restrictions, because of the work done in eradicating ticks, sell over $525,000 worth of cattle annually. If the loss caused by the ticks and the quarantine restrictions amounted to only one-eighth of a cent a pound, and it probably amounted to much more, it meant a loss on the cattle sold by these counties of not less than $25,000 annually, which is much more than the entire amount expended in eradicating the ticks.

Briefly stated, the method of extermination found most applicable to our condition is as follows: Inspectors are employed who make a farm to farm canvass of the territory with a view to locating all tick-infested farms, which are at once quarantined and the owners carefully instructed as to the importance and object of the work, and especially as to the easiest and best means of exterminating the ticks on their farms.

For killing the ticks the methods found most applicable to the conditions existing in this State and which will apply in the other Southeastern States are as follows:

1. Keep all cattle, horses and mules out of the tick-infested pastures, lanes and lots after September 1st, or better, after August 15th, and all eggs previously laid will hatch before cold weather and the young ticks starve to death by May 1st.

2. Divide the pasture by a fence with a rail or board tight on the ground, or by two fences 15 to 20 feet apart, and the first year keep all cattle, horses and mules out of one-half after August 15th. The

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second year, after May 1st, put the cattle on the half left vacant the year previous, and also provide new lanes and lots on ground over which no cattle ran the year before.

One wire fence may be used for dividing the pasture if before the cattle are turned into the free part in the Spring this fence be moved back fifteen or twenty feet on to the part left unoccupied the fall before.

3. If practicable, burn the pasture over thoroughly early in the spring. Begin not later than April 15th or August 15th greasing the legs and underparts of the bodies of all cattle and repeat it once a week until the ticks entirely disappear, three or four months. While greasing the cattle look carefully for any ticks that may have escaped the grease or attached themselves to the upper parts of the body, and if any are found, pick them off and burn. The grease may be Beaumont crude oil or one part kerosene and three or four parts any cheap sort convenient, such as cotton-seed oil. If a little sulphur and tar be added the effect will be prolonged and increased. The grease prevents young ticks attaching themselves to the cattle and kills those already on by plugging the small openings in the body through which they breathe.

If the greasing and hand-picking be done thoroughly and no ticks allowed to drop in the pastures, lanes or lots for four months during the warm season or for eight months in winter, the effort will be successful.

Either of the first two methods, when it can be adopted, is always certain to exterminate the ticks; but the third is not applicable to large herds, and will fail unless it be carefully and thoroughly carried out.

If the herd be large and a change or division of the pasture is impracticable, but it is still desired to exterminate the ticks, or at least reduce their numbers and thereby lessen their depleting effects on the cattle, much good may be done by an occasional spraying with kerosene emulsion or dipping in Beaumont crude oil. Both these methods of attacking the ticks necessitate considerable expense for apparatus, which is only justified when the herd is large. Moreover, no satisfactory substance has yet been found for use as a dip or spray when the complete destruction of the ticks in a pasture is aimed at, because the frequent applications necessary are injurious to the cattle.

Very respectfully,

TAIT BUTLER,
Veterinarian.

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REPORT OF THE POULTRY DIVISION.

PROF. B. W. KILGORE, *Director.*

DEAR SIR:—I beg to submit the following report of the work in the Poultry Division for the year ending June 30, 1906:

I am glad to be able to report that the improvement in the health of our flock, which I reported last year, has continued and that we have not had any outbreak of disease among our fowls the past year.

One building has been erected during the year for the accommodation of the male birds when not in use in the breeding pens.

I believe that it is an advantage in any case to have the males away from the females at all times except when the eggs are wanted for hatching, but it is specially necessary in warm climates during the summer months if the eggs are to get to market in good condition.

During the summer it is quite common for eggs in transit to become warm enough to start the germ to grow and when the egg becomes cooled the germ dies and putrification at once starts and it is therefore no uncommon thing for eggs that left the shipper in good condition to reach the market in a damaged state and bring several cents per dozen less than sound eggs are selling for. We have losses in the poultry business that are hard to avoid, but this is not one of them as the remedy is simply to keep the male birds away from the hens through the warm weather.

In order to test the relative keeping qualities of fertile and infertile eggs the male was left in one pen when we broke up our breeding pens at the end of the hatching season and the eggs from this pen were gathered and put up with an equal number from the pens from which the males had been removed, and although the conditions were favorable to the fertile eggs, as all were kept in a fairly cool cellar, it was found that while all the infertile eggs were good fifteen per cent of those fertilized, or from the pen where the male was with the hens, although all the eggs may not have been fertile, were entirely unfit for use and most of the others were of inferior quality.

Pedigree breeding for egg production was started this year, trap nests being used so that an accurate record of the eggs laid by each hen could be kept. Those that were found to be the best layers were kept over for breeders the next year and the chicks from them will be marked so that they can be identified when we come to mate our birds for the next season's work.

Our two best layers were barred Plymouth Rocks and taking them as a pen they were also at the head of the list, that is, they not only had the best individual record, but the best average for the pen. White Plymouth Rocks were second and not far behind the barred.

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This work has brought out a point that I have tried to impress on persons who have asked which breed is the best for egg production, viz: That there is often more difference between birds of the same breed than there is between different breeds and that it is a matter of individual selection. The barred Plymouth Rocks had the best record and several of them laid over sixty per cent during the winter months, but then we had one of the breed that never laid an egg all the year and another that laid only about a dozen.

Owing to the improved health of the flock we had a much larger number of chickens to dispose of in the fall, all of which were disposed of to the farmers and poultrymen of this and the adjoining States at fair prices.

The present spring and summer have been unusually bad for poultry raising on account of the very wet weather and we have had as a consequence a great many inquiries as to the prevention and cure of diseases caused by this condition. In a number of cases we were able to recommend treatment that to a large extent enabled the raisers to avoid the troubles that had been causing serious loss in their flocks.

I attended and spoke at a larger number of Farmers' Institutes this year than previously and the schedule for the coming year, including as it does the meetings for women, calls for a much larger number of talks than were given this year.

No additions to the varieties of poultry kept has been made this year, but the rapid growth in popularity of the Rhode Island Reds, as shown by the larger number exhibited at our Fairs and Poultry Shows and by the increasing number of inquiries that we receive for them, makes me think that we should add this breed to those already kept.

The work planned for the coming year is a continuation of the pedigree breeding for egg production, dry feeding from hoppers in comparison with mash feeding for laying hens, hopper feeding for brooder raised chicks, tests of the value of green food in winter, both as to the number of eggs laid and the percentage of fertility and the number of chicks hatched and a comparison of different methods of cooling and turning eggs in incubators.

Respectfully submitted,

J. S. JEFFREY,
Poultryman.

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REPORT OF THE ENTOMOLOGICAL DIVISION.

DIRECTOR W. B. KILGORE.

SIR:—I herewith submit statement of the work carried on in the Entomological Division of the Station during the past year:

From August, 1905, to June, 1906, I was not in the State, the work being carried on by Mr. R. S. Woglum, Acting Entomologist, to whom credit is due for all work accomplished in that time.

As in previous years much time is taken up in the routine office and laboratory work and the work of nursery inspection. The correspondence has continued to be large, a great number of letters being constantly received asking information concerning various pests to all sorts of crops and products.

The reference collections continue to grow in volume and in value. It is our intention to continue this work at spare times until our collections shall represent, as completely as may be possible, the entire insect fauna of the State.

Instruction at the Agricultural College was carried out as heretofore, courses being offered in three separate classes in the College.

Experiments to test the comparative value of several different mixtures for control of San Jose Scale were carried on at Southern Pines, and it is hoped that the results may be published soon.

Comparative tests of jarring and spraying methods of combatting the Curculio on peach trees have been made this spring, and it is hoped that the results will warrant some change in the costly methods now in common use. Another season's work may be needed before the results of these tests should be published.

The resignation of Mr. Bentley a year ago, and my own leaving a month or two later, altered the plans made for an extended inquiry into the bee-keeping industry as it now exists in the State. However, two colonies of bees have been started on the balcony of the Department of Agriculture building, and we will likely later make some changes in the management of the swarms at the Station farm. But apiculture is in reality a science in itself and if it were desired to conduct a thorough inquiry into the industry in this State and to make actual investigations of use to bee-keepers, an expert bee-keeper should be employed for that work. The time does not now seem to be ripe for such a step.

Respectfully submitted,

FRANKLIN SHERMAN, JR.

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NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATIONS, 1905-1906.

DR.

To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ending June 30, 1906, as per Acts of Congress, approved March 2, 1887, and March 16, 1906.

Hatch Fund $15,000.00
Adams Fund 5,000.00

CR.

	Hatch Fund.	Adams Fund.
By Salaries	$9,766.69	$965.32
Labor	1,778.85	
Publication	553.92	
Postage and stationery	434.90	
Freight and express	71.06	9.84
Heat, light and water	91.10	
Chemical supplies	82.25	518.14
Seeds, plants and sundry supplies	301.61	34.08
Fertilizers	211.73	308.57
Feeding stuffs	619.77	
Library	39.41	313.15
Tools, implements and machinery	206.94	1,484.02
Furniture and fixtures	128.82	
Scientific apparatus	17.27	964.41
Live stock	53.00	175.00
Travelling expenses	223.30	
Contingent expenses	15.00	
Building and repairs	404.88	282.52
Total	15,000.00	5,000.00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1906; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $20,000, and the corresponding disbursements $20,000; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the act of Congress, approved March 2, 1887, and March 16, 1906.

(Signed) S. L. PATTERSON,
B. W. KILGORE,
Auditors.

(Seal.)

Attest: A. F. BOWEN, *Custodian.*

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Bulletin No. 193. **February, 1906.**

NORTH CAROLINA

Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts

RALEIGH

Spraying Mixtures and Machinery.
When and How to Spray.

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N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

S. L. PATTERSON, *ex officio* Chairman, Raleigh.

J. M. FOREHAND ..... Tyner.	A. T. MCCALLUM ..... Red Springs.
J. B. STOKES ..... Windsor.	J. P. MCRAE ..... Laurinburg.
WM. DUNN ..... Newbern.	R. L. DOUGHTON .... Laurel Springs.
C. N. ALLEN ..... Auburn.	W. A. GRAHAM ..... Machpelah.
R. W. SCOTT ..... Melville.	A. CANNON ..... Horse Shoe

STATION STAFF.

GEORGE T. WINSTON, L.L D., President of the College.

B. W. KILGORE ..... Director.
W. A. WITHERS ..... Chemist.
C. W. BURKETT ..... Agriculturist.
TAIT BUTLER ..... Veterinarian.
F. L. STEVENS ..... Biologist.
H. H. HUME ..... Horticulturist.
J. S. JEFFREY ..... Poultryman.
R. S. WOGLUM ..... Acting Entomologist.
B. F. WALTON ..... Assistant in Field Experiments.
J. C. KENDALL ..... Assistant Dairy Husbandry.
O. L. BAGLEY ..... Assistant Chemist.
R. H. HARPER ..... Assistant Chemist
A. F. BOWEN ..... Bursar.

The Director's office is in the Agricultural Building, Raleigh: the experiment grounds and laboratories being at the Agricultural College, just west of town and on the street car line.

Visitors will be welcome at all times, and will be given every opportunity to inspect the work of the Station. Bulletins and Reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

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Mixtures and Machinery.

When and How to Spray.

BY

F. L. STEVENS, Biologist,

AND

R. S. WOGLUM, Acting Entomologist.

INTRODUCTION.

The constant demand by people from all parts of the State for information as to what spray to use in combating the different insect and fungous troubles, and how to make their spraying mixtures, has led to the preparation of this bulletin. The information is given in a brief but accurate manner. For more detailed accounts special bulletins issued by this Station should be consulted. They will be sent gratis upon application.

An attempt has been made to set forth the more important insect pests and fungous troubles in such a way that it can be seen at a glance what spray to use and when to apply it. In this direction one point should be constantly held in mind: **Whenever an insecticide and a fungicide are to be used at the same time, it is usually possible, provided the insecticide is an arsenate compound, to combine the two, so that only one application is necessary.**

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WHEN AND WHAT TO SPRAY.

APPLE.

Scab, Leaf Spot, Sooty Fungus: Use copper sulfate 1-25 before buds open. Bordeaux just before blossoms open, again seven days after blossoms drop; repeat every ten to fourteen days. **Rust:** Cut out cedar trees if possible. **Bitter Rot** and **Ripe Rot:** Spray as above, cut out canker and avoid bruising.

Aphis: Apply 15 per cent kerosene emulsion when lice appear; treat root form by removing dirt at base of tree until roots are exposed; sprinkle on tobacco stems and replace dirt. **Canker Worm:** Use Paris green or arsenate of lead as soon as first caterpillars appear; repeat after five days. Band trees before moths appear in spring. **Codling Moth:** Paris green or arsenate of lead as soon as blossoms fall; repeat in ten days. **Curculio:** See Plum. **Fall Web-Worm:** Arsenate of lead on leaves around nest, or destroy nest by burning. **Oyster-Shell Scale:** Use 15 per cent kerosene emulsion as soon as young hatch in spring; repeat when necessary. **San Jose Scale:** Lime-sulphur-salt in spring just before buds swell. **Scurfy Scale:** Same as for Oyster-Shell Scale. **Tent Caterpillar:** Same treatment as for Fall Web-Worm. **Tussock Moth:** When caterpillars appear spray with arsenate of lead or Paris green. Destroy egg masses in winter. Band trees to prevent ascent of female moths.

ASPARAGUS.

Rust: If you are troubled with this disease write to the Station for special directions.

Beetle: Dust frequently with pyrethum for worms. Destroy all uncultivated stocks. After cutting has stopped, spray with arsenate of lead or Paris green.

BEAN.

Anthracnose, Leaf Blight: Bordeaux every ten or fourteen days after plants are four inches high and until pods are half grown.

Leaf Beetle: Use Paris green, 1 pound to 150 gallons water.

NOTE—When lime, sulfur and salt is used before buds open, the first application of copper sulphate is not needed. Any arsenate for insects may be applied in Bordeaux mixture.

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Striped Cucumber Beetle: See Cucumber. **Weevils:** Fumigate seed with carbon bisulphide.

BLACKBERRY, RASPBERRY, DEWBERRY.

Leaf Blight, Anthracnose: Copper sulfate 1-25 just before leaf buds open; just before blossoming and after harvesting use Bordeaux. Use weak Bordeaux on young canes when six inches high.

Rust: Dig and burn plants.

Anthracnose: Cut out infested canes.

CABBAGE.

Club Foot: Rotate crops.

Harlequin Cabbage Bug: Plant early trap strip. When beetles are numerous spray with pure kerosene. **Plant Lice:** When plants are young use 10 per cent kerosene emulsion; after headed, tobacco water. **Root Maggot:** Pour around base of plants an emulsion of 1 pound soap, 1 gallon boiling water, and 1 pint crude carbolic acid, or inject carbon bisulphide in ground near base of plant. **Worms:** Paris green when plants are young; when headed dust on hellebore or pyrethum.

CELERY.

Leaf Spot: Bordeaux on young seedlings and repeat every ten or fourteen days.

CHERRY.

Brown Rot, Shot Hole: Use copper sulfate 1-25 before buds open. When fruit is set use Bordeaux mixture. Repeat every ten or fourteen days until two-thirds grown.

Black Knot: Cut out and burn.

Aphis: Kerosene emulsion 15 per cent when insects appear; repeat when necessary. **Curculio:** See Plum. **San Jose Scale:** See Apple. **Slug:** Arsenate of lead or Paris green at first appearance.

CHRYSANTHEMUM.

Leaf Spot: Bordeaux every ten or fourteen days.

CORN.

Red Spider: See Cotton. **Weevil:** Use carbon bisulphide.

COTTON.

Lice: Use 10 per cent kerosene emulsion. **Red Spider:** Lye-sulphur wash as soon as first appear. Spray both plants infested and

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those immediately adjoining. **Caterpillar:** Paris green 1 pound to 60 gallons water; or as a dust mixed with dry air-slaked lime, or flour.

COWPEAS.

Bean Leaf Beetle: See Bean.

CUCUMBER.

Anthracnose, Downy Mildew, Fruit Spot: Bordeaux when vines are one-half yard long; repeat every ten or fourteen days as need be.

Aphis: Use 10 per cent kerosene emulsion. **Striped Cucumber Beetle:** Use Bordeaux mixture and Paris green frequently. **Spotted Cucumber Beetle:** Same as for Striped Beetle.

CURRANT AND GOOSEBERRY.

Worm: Bordeaux mixture and Paris green when worms appear; when fruit is formed use hellebore.

GRAPE.

Black Rot, and other Fungous Diseases: Copper sulfate 1-7 before leaf buds open. Bordeaux 6-4-50 before blossoming, again ten or fourteen days after blossoming and every ten days thereafter until the middle of July.

Destroy old leaves and rotten grapes, or cover what cannot be destroyed by cultivating.

(Write for bulletin 185 of this Station.)

Aphis: Use 15 per cent kerosene emulsion. **Berry Moth:** Use arsenate of lead, 4 pounds to 50 gallons water, just before blossoms open; repeat after petals fall. **Flea Beetle:** When buds begin to swell use Paris green, 1 pound to 75 gallons water, or arsenate of lead; when worms appear on leaves repeat. **Leaf Hopper:** Whale oil soap 1 pound to 10 gallons water; apply to under surface of leaves. **Root Worm:** As soon as beetles appear use arsenate of lead, 4 pounds to 50 gallons water. Repeat ten days later. **Rose Beetle:** See Rose.

LETTUCE.

Aphis: Spray with tobacco water. **Harlequin Cabbage Bug:** See Cabbage.

MUSKMELON.

See Cucumber.

ONION.

Maggot: Treat in same way as Cabbage Maggot.

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NURSERY STOCK.

Fungous Diseases: Bordeaux when leaves are out. Repeat every ten or fourteen days.

Plant Lice: Use 15 per cent kerosene emulsion. **San Jose Scale:** Fumigate with hydrocyanic acid gas, or destroy.

OATS.

Smut: Use formalin. (Write for Special Bulletin.)

PEACH.

Curl, Brown Rot, Mildew, Scab: Copper sulphate 1-25 in early spring before leaf buds open; as blossoms fall use weak Bordeaux. Repeat every ten or fourteen days until fruit is two-thirds grown.

Rosette
Yellows
Little Peach } Dig out and burn as soon as recognized.

Brown Rot: Destroy dead peaches on ground under tree in earliest spring or autumn.

Black Peach Aphis: Treat as for Apple Aphis. **Curculio:** See Plum. **San Jose Scale:** See Apple.

PEAR.

Leaf Blight, Scab: Use Bordeaux when leaves are half grown; again just before blossoming; again after fall of blossoms.

Blight: Cut and burn.

Fall Web-Worm: See Apple. **Leaf Blister Mite:** In spring just before buds break use 20 per cent kerosene emulsion. **San Jose Scale:** See Apple. **Scurfy Scale:** See Apple. **Slug:** Paris green or arsenate of lead when insects appear; repeat if necessary.

PLUM.

See Cherry. **Black Knot:** Cut and burn. **Pockets:** Cut out.

Curculio: Arsenate of lead just before blossoms open; repeat after petals fall. Follow second spray by jarring trees. **San Jose Scale:** See Apple.

POTATO—(IRISH).

Blights: Use Bordeaux mixture when six inches high; repeat every ten or fourteen days till end of growth, using Paris green and Bordeaux when **insects** appear.

ROSE.

Mildew: Potassium sulfide before leaves open and repeat if need be.

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Aphis: Use 15 per cent kerosene emulsion. **Rose Bug, or Chafer:** As soon as beetles appear use arsenate of lead, 4 pounds to 50 gallons water; repeat in five to seven days. **Rose Scale:** Spray with 20 per cent kerosene emulsion in spring just before buds break. When young appear use 15 per cent kerosene emulsion. **Slug.** Spray with Paris green or tobacco water; or dust on hellebore.

STRAWBERRY.

Fungus Diseases: Use Bordeaux early, and again just before first blossoms open.

TOMATO.

Rot: Bordeaux before appearance of rot and repeat every ten or fourteen days.

TOBACCO.

Flea Beetle: Same as for potato Flea Beetle. **Horn Worm:** Paris green 1 pound to 160 gallons water. **Cigarette Beetle:** Carbon bisulphide.

WATERMELON.

(See Cucumber.)

NOTE.—When lime, sulphur and salt is used before buds open, the first application of copper sulphate is not needed. Any arsenate for insects may be applied in Bordeaux mixture.

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FUNGICIDES.

The efficiency of fungicides depends upon the fact that many plant diseases are caused by fungi. These fungi gain entrance to the plant at the surface by means of reproductive bodies called spores. The fungicide is a mixture which is spread upon the surface of the plant which by its poisonous properties prevents the spores from successfully germinating and gaining entrance into the plant.

Spraying for fungous diseases is recognized, by the successful horticulturist, as a necessary measure.

BORDEAUX MIXTURE.

This mixture, which takes its name from its place of discovery, Bordeaux, in France, is the most widely used and with certain limitations the most effective fungicide. It consists of copper sulfate (blue vitrol or blue stone) and quick lime mixed with water in various proportions.

The chief strengths of Bordeaux are as follows:

4—4—50.

Copper sulfate or blue stone	4 pounds.
Quick lime	4 pounds.
Water	50 gallons.

This strength may be used on most plants the foliage of which is not susceptible to injury.

6—4—50.

Copper sulfate or blue stone	6 pounds.
Quick lime	4 pounds.
Water	50 gallons.

This second is particularly for grapes.

Those plants with delicate foliage, such as the peach, plum, cherry and apricot, demand weaker solutions, consisting of

2—2—50.

Copper sulfate	2 pounds.
Lime	2 pounds.
Water	50 gallons.

Or—

2½—6—50.

Copper sulfate	2½ pounds.
Lime	6 pounds.
Water	50 gallons.

There is no certainty as to which of these strengths is best. To most crops no damage can come from the use of as strong a solution as

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6—4—50, yet it is possible that all of the good can be accomplished by the 4—4—50. If so, there would be a loss of material through the use of the stronger solution. This matter is open to experimentation.

In the preparation of the Bordeaux mixture, it is well to have on hand stock solutions of copper sulfate and lime. The stock solution of copper sulfate should be made by dissolving a certain number of pounds of copper sulfate in one-half the number of gallons of water. —For example: 80 pounds copper sulfate in 40 gallons of water. Every gallon of this stock solution will contain 2 lbs. of copper sulfate, and the necessity of further weighing is avoided. The stock solution will remain good for any length of time if water evaporated is replaced. In order to dissolve the copper sulfate, it is best to tie it in a coarse bag and suspend it near the top of the liquid. In this way it will dissolve in a few hours. If it is placed in the bottom of a barrel it will dissolve but slowly, even with constant stirring. It is well to dissolve the copper sulfate the night before you are ready to make the mixture, and it will then be ready in the morning.

In a similar way a stock solution of lime should be made. Quick lime of good quality, which is not at all slacked, should be weighed out and placed in a trough and slaked slowly, using a very small quantity of water. By slaking slowly a finer quality of lime is secured. After the lime is thoroughly slaked it should be mixed with enough water to make a putty-like mass. This may be covered with more water to keep out the air and may be used when needed. Since this mass was originally weighed, you can estimate nearly enough for any given amount of Bordeaux mixture.

In preparing the Bordeaux mixture from stock, measure out the proper amount of stock solution of copper sulfate, and dilute it with half the amount of water needed. In a similar way measure out the proper amount of lime needed from the stock and dilute it with the other half of water in a separate vessel.

The lime should be passed through a fine wire strainer of about thirty meshes to the inch, or through cheese cloth, in order to remove the particles of stone, or it will otherwise cause great difficulty in the pump nozzle when spraying.

We now have the two ingredients each mixed with one-half the amount of water called for in the formula. All that remains is to mix these two solutions. They should be poured together slowly and thoroughly stirred.

It is a matter of considerable importance that the stock solutions be diluted before they are mixed with each other. The quality of Bordeaux mixture resulting from this method is superior in several respects to that which would be made if strong solutions were mixed together and afterwards diluted.

The Bordeaux should be freshly made each time before using.

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SODA OR POTASH BORDEAUX MIXTURE.

While the Bordeaux mixture is eminently successful in preventing many plant diseases, slight difficulty is sometimes encountered owing to the occurrence of small stones, resulting from imperfections in lime. These, if not thoroughly strained out, clog the spraying nozzle and are troublesome. To escape this difficulty and to render the preparation and application of the Bordeaux mixture easier, as well as to give a mixture suitable for use as the fruit approaches maturity, the use of potash of soda as substitutes for the lime has been recommended.

THE SODA BORDEAUX.

Copper sulfate (blue stone) ..... 5 pounds.
Commercial caustic soda sufficient to combine with copper sulfate and leave a slight excess of soda.
Water ..... 50 gallons.

It will be noted that the amount of caustic soda to be used is not stated definitely. It is impossible to make a definite statement, as the strength of the various commercial sodas varies greatly.

The following table, however, gives the amount of copper sulfate required for a single can of several of the more common sodas. In the last column is found the amount of mixture which a can will make. For example, if you choose to use the Champion soda, a can of which weighs 13.73 ounces, you should use 1.6 pounds of copper sulfate to each can of soda. One can of soda contains 12 ounces of substance and the 1.6 pounds of copper sulfate together with the one can of Champion soda will make thirteen gallons of soda Bordeaux.

In a similar way, by consulting the table you may find how much copper sulfate to use per can with any of these brands and how much mixture it will make.

	Gross Weight of Can.	Weight of Substance.	Copper Sulfate Required.	Amount of Mixture.
Soda (Troy)	11.2 lbs.	10.17 lbs.	46.22 lbs.	462 gal.
Babbitt's Potash	17 oz.	14.5 oz.	3 "	30 "
Champion	13.75 "	12 "	1.6 "	13 "
Red Seal	17 "	14.5 "	2.4 "	24 "
Leggett's	17 "	14.75 "	2.5 "	25 "
Lehman's	14.75 "	12.25 "	2.4 "	24 "
Hirsh	14.5 "	12.75 "	1.8 "	18 "
Washington	14.25 "	12.75 "	1.7 "	17 "
Saponifier (Solid)	15.75 "	14.25 "	2.5 "	25 "
Saponifier (Granulated)	17 "	14.75 "	2.6 "	26 "
Natrona	42.75 "	36.75 "	7.2 "	72 "

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Dissolve the caustic soda in water. Dissolve the copper sulfate also in water in another vessel and dilute each to half the volume of the completed mixture, then mix the two solutions together.

If you put together in the above proportions the mixture will be alkaline. If too little soda is used the mixture will be acid, and is then liable to injure the leaves.

In order that the mixture may be more easily seen on the trees, and thus enable the operator to know when the tree has been completely sprayed, add a small quantity of lime, about one-half pound to every fifty gallons of mixture. This will be sufficient to make a visible deposit on the trunk and foliage of the tree, and enable one to distinguish easily the sprayed from the unsprayed portions of the tree.

The strength as given above is really the same as the 5—5—50 Bordeaux mixture. If you prefer to use one comparable to the 4—4—50, increase the amount of water by 25 per cent.

AMMONIACAL SOLUTION OF COPPER CARBONATE.

This solution contains no sediment, and on drying leaves no marks upon the fruit. It may therefore be used upon fruits in the latter stages of their ripening, when the spotting that the Bordeaux mixture causes would preclude the use of that fungicide. The mixture consists of a solution made by dissolving copper carbonate in ammonia water in the following proportions:

Copper carbonate	6 ounces.
Ammonia (about)	3 pints.
Water	50 gallons.

Weigh out the proper amount of copper carbonate, set a very small portion of this aside, and dissolve the remainder of it in diluted ammonia, using only enough to dissolve it, and then add the portion of copper carbonate which was reserved. This will insure that you use no more ammonia than is necessary. It is better to have a little too much of the carbonate in the solution than to have too much ammonia. A strong solution made in this way can be diluted with the proper amount of water. The copper carbonate may be purchased directly from the drug store, or it may be prepared on the farm.

To make copper carbonate proceed as follows: Dissolve ten pounds of copper sulfate (blue stone or blue vitrol) in ten gallons of water. Also dissolve twelve pounds of carbonate soda in the same amount of water. Allow these two solutions to cool, and then mix them slowly together, stirring in the meantime. Allow the mixture to settle about twelve hours, then pour off the liquid and add water equal in amount to the liquid poured off. Stir thoroughly and allow it to settle as before. Repeat this operation again, then drain off all of

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the liquid possible, and dry the blue powder which remains. This powder is the copper carbonate.

COPPER SULFATE SOLUTION.

1—17.

A solution consisting merely of copper sulfate and water may be used before the leaves appear, to kill the spores on the trunks and branches of the trees.

Copper sulfate	1 pound.
Water	17 gallons.

Dissolve the copper sulfate as you do in preparing the Bordeaux mixture, dilute it to the required strength, and spray upon the trees. The addition of a little lime, say half a pound to fifty gallons of mixture, enables the operator to see exactly what portions of the tree have been sprayed.

This mixture must not be used after the leaves appear.

COPPER SULFATE.

1—7.

Made as above, but using 7 instead of 17 pounds of copper sulfate.

POTASSIUM SULFIDE SOLUTION.

Potassium sulfide (or liver of sulphur)	1 ounce.
Water	2-4 gallons.

This solution should be freshly prepared. It is used as a substitute for the Bordeaux mixture in the same way as the ammoniacal solution of copper carbonate is used, when the fruit has become so large that the Bordeaux mixture must be discontinued to avoid spotting. Potassium sulfide is especially efficient as a protection against the powdery mildews.

FORMALIN.

Formalin is a very powerful germicide which recently came into wide use. Its interest to the farmer lies chiefly in its value in preventing the potato scab, the onion smut, and the various smuts of cereals. Full directions for using this are found in other bulletins of this Station.

Two forms of this substance appear on the market. One under the name of formalin, and the other under the name of 40 per cent formaldehyde. These substances are absolutely identical, and as the 40 per cent formaldehyde is cheaper, owing to the fact that the word formalin is protected by a patent, the farmer, of course, will do well to use the 40 per cent formaldehyde.

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INSECTICIDES.

The choice of the spray mixture to be used in fighting insect pests depends largely upon a principle little understool by the average farmer, and yet to the entomologist it is the first thing to be considered. It is "in what form does the insect to be fought take its food, as solid matter, or by sucking the juices from the plant?"

On this principle insects fall into two classes which are separated by the character of their mouth parts: (1) *Biting Insects* include those whose mouth parts are in the form of jaws by means of which they bite from the leaves of plants pieces which are taken into the stomach. Examples: grasshoppers, cabbage worms, and tobacco worms. (2) *Sucking Insects* include those whose mouth parts are in the form of a beak, or needle-like apparatus, which they insert in the plant and derive therefrom the juices. Examples: plant lice, scale insects, and harlequin cabbage bug. In the former case the poison is applied to the foliage so as to be taken into the stomach along with the food. These poisons are called stomach poisons, and the articles most commonly used are compounds of arsenic: as Paris green, London purple, or arsenate of lead.

With the sucking type of insect a different method of treatment must be followed. Poison on the surface of the plant has no effect on these "sap-suckers," as they derive their food from within the plant. Since we are not able to put the poison inside the plant tissue to be sucked in by the insect with the juices, the only thing to do is to use some substance which will kill the insects by acting externally on their bodies. Arsenic poisons will *not* accomplish this purpose. The best contact poisons are such as soaps or oils.

FOR BITING INSECTS.

Paris Green.

Paris green	1 pound.
Water	60-250 gallons.
Fresh stone lime	1 pound.

Slake the lime in the usual way by adding water (either warm or cold). Warm water will cause the lime to slake much more readily than cold. Strain the slaked lime through cheese cloth into a pail, and pour in enough water to nearly fill the pail. Add the green (which should first be made into a paste by the addition of a little warm water) and stir thoroughly. Then pour this mixture into the required amount of water and the resultant is ready for use. The lime is added to prevent the green burning the foliage of the plants sprayed. In the case of some plants, however, the pure green at the

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concentration used will not injure the foliage, thus making the addition of lime unnecessary. Unless the farmer is thoroughly acquainted with the different resistant plants it is better to add the lime. In case of doubt add lime.

London Purple.

London purple	1 pound.
Water	60-200 gallons.
Fresh stone lime	2-3 pounds.

This mixture is made in the same way as Paris green. Its more caustic properties makes necessary the addition of two or three times its weight of lime. Never fail to add the lime whatever sort of plant is sprayed. London purple is somewhat cheaper than Paris green, yet because of the fact that its chemical composition varies from time to time, and hence it cannot be relied upon to always give good results, use the latter poison where obtainable.

Arsenate of Lead.

Acetate of lead	12 ounces.
Arsenate of soda	4 ounces.
Water	50 gallons.

Put the acetate of lead into a gallon of water in a wooden pail; in another wooden pail put the arsenate of soda in two quarts of water. When both are dissolved, pour them together into the spray tank containing the required amount of water. A white precipitate of lead arsenate immediately forms in the tank and the mixture is ready to be applied.

Arsenate of lead has some advantages over all other arsenic mixtures. *It is absolutely harmless to foliage even when applied in large quantities,* and its finely divided condition causes it to remain in suspension many times longer than Paris green, London purple, or most of the other arsenic compounds.

On the market there are now found several kinds of arsenate of lead ready for use; sometimes in the form of a dry powder, sometimes in the form of a paste. "Swift's Arsenate of Lead," and "Disparine," a preparation made by the Bowker Insecticide Company, of Boston, are two forms of the paste. Both are excellent preparations and are very effective. However, their greater cost than the home-made material usually makes it advisable to use the latter.

Arsenite of Lime.

White arsenic	1 pound.
Fresh stone lime	2 pounds.
Water	2 gallons.

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Slake the lime; then put the slaked lime and arsenic into a gallon of water and boil 40 minutes. Remove, and add water enough to make two gallons stock solution. *Use one quart of this stock solution to fifty gallons of water.* Arsenite of lime at this strength compares favorably with Paris green where used at the rate of one pound green to one hundred and fifty gallons of water. Its main recommendation is its low cost, being the cheapest of the arsenic compounds. When improperly made arsenite of lime is liable to burn the foliage, hence carefulness in preparation is a necessity. Do not boil ten or fifteen minutes, *but boil the entire forty minutes,* to make certain that the arsenic has been dissolved.

Arsenite of Lime with Soda.

White arsenic	1 pound.
Sal soda	4 pounds.
Water	2 gallons.
Fresh stone lime	2 pounds.

Dissolve the sal soda in a gallon of water, add one pound of white arsenic and boil fifteen minutes, or until the arsenic has dissolved. Then add two pounds of fresh slaked lime and boil fifteen minutes more. Remove and add water to make two gallons stock solution. *Use one quart stock solution to fifty gallons of water.*

This mixture has practically the same properties as arsenite of lead without the soda, and can be used wherever the latter is. The addition of soda, however, renders the mixture less liable to injure foliage. As in the case of the preceding mixtures, it can be safely used if carefulness in preparation is observed.

Hellebore.

Fresh white hellebore	1 pound.
Water	2 gallons.

Steep the hellebore in a quart of boiling water and add the rest of the water when ready to spray. Hellebore may also be dusted on the plants as a dry powder, and at its full strength. Where the powdered form is used it should be applied when the plants are moist with dew.

FOR SUCKING INSECTS.

*Lime-Sulfur-Salt Wash.

Stone lime	20 pounds.
Sulfur (flowers)	17 pounds.
Salt	10 pounds.
Water (to make)	50 gallons.

*Write for Entomological Circular No. 13.

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Mix the sulfur with five or six gallons of hot water in a large iron kettle over a fire. Add the lime, and as it slakes dash in cold water as needed to prevent boiling over, and to keep to a thin liquid consistency. As slaking ceases add the salt, and boil forty minutes longer. Keep stirring frequently. Then strain, and add water to make fifty gallons. Spray while warm or hot.

This wash is sometimes made without the salt, and some authorities hold that their success in its use has been as marked without the addition of salt as with salt. Salt adds to the sticking quality of the wash, and it is not definitely known but that the combination of lime and sulfur is favorably influenced by it. We recommend the addition of salt. Lime, sulfur and salt is a winter wash, and should consequently be applied to trees only when they are in a dormant condition. It is the best known insecticide for the San Jose scale. Besides its insecticidal value, it also has a certain effect as a fungicide.

LIME, SULFUR AND SODA.

Stone lime	30 pounds.
Sulfur	17 pounds.
Caustic soda	6 pounds.
Water	50 gallons.

Pour some hot water onto the lime, and as soon as it begins to slake add the sulfur (which should be made into a thin paste by means of water). Stir thoroughly and continually. When the lime is nearly slaked, add the caustic soda, part at a time. Hot water should be added as needed to keep it to a liquid consistency. When boiling has ceased, the proper amount of water (preferably hot) should be added to make fifty gallons.

This wash is sometimes used in place of the fire or steam boiled lime, sulfur and salt wash. However, it is not quite as effective as the latter, and should not be used where the latter is obtainable.

*KEROSENE EMULSION.

Kerosene	2 gallons.
Water	1 gallon.
Soap	½ pound.

Shave the soap into the water and heat to boiling to dissolve. When dissolved, remove from the fire and pour in the kerosene. Churn together very thoroughly by putting the material into the spray pump, and pumping the emulsion back into itself for several minutes. Before using, this emulsion should be diluted to the strength needed. To get 10 per cent oil, add 17 gallons of water. To get 15 per cent, add 10½ gallons of water. To get 25 per cent, add 5 gallons of water.

* Write for Entomological Circular No. 10.

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Kerosene and Water.

A mixture of kerosene and water can be used in those cases where kerosene emulsion is employed, and at the dilution recommended for the latter. The mixture is made with the use of a spray pump built especially for that purpose, which has a kerosene attachment. As these pumps cannot always be relied upon to give a uniform amount of kerosene it is advisable to leave them alone.

Whale Oil Soap.

Whale oil soap	1 pound.
Water	2-6 gallons.

Dissolve the soap in hot water.

Lye-Sulfur.

Flowers of sulfur	20 pounds.
Caustic soda	10 pounds.

Make the sulfur into a paste with cold water, and then add the soda. Dash in cold water from time to time to prevent burning. When boiling has ceased, add water enough to make 20 gallons of stock solution. Use two gallons of this mixture to 50 gallons of water. This wash is used principally for the red spider.

Tobacco.

Put tobacco stems in a water-tight vessel, pour in boiling water enough to cover the tobacco, and allow to stand several hours. Dilute two or three times before using. Tobacco may also be used as a finely ground powder.

BOTH FOR BITING AND SUCKING INSECTS.

Pyrethum.

Pyrethum is usually applied as a dry powder at its normal strength, or it may be mixed with twice its bulk of flour and then used. Used as a spray, water is added in the following proportions:

Pyrethum	1 pound.
Water	3 gallons.

Keep the powder in a tightly-corked can. If exposed to the air it soon loses its effect. The high cost of pyrethum restricts its use more especially to plants grown indoors.

Carbon Bisulphide.

Use at the rate of 1 pound of bisulphide to 1,000 cubic feet of space. Where a smaller area is to be covered use about a teaspoonful to each cubic foot of space. Place in shallow dishes on top of the grain to be treated. The fumes are heavier than air and thus will penetrate throughout the box. The box or closet in which the grain

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is treated should be tight. After leaving 24 hours, open, and air for half an hour before using. Do not use a fire of any kind, not even a lighted cigar or pipe, near the fumes.

Hydrocyanic Acid.

This gas is used especially in fumigating nursery stock, in treating fruit trees, and in green-houses. With nursery stock the following proportion is used:

Cyanide of potassium	1 ounce.
Sulphuric acid	2 ounces.
Water	4 ounces.

Pour the water into a glass or earthenware dish and add the sulphuric acid. Drop in the cyanide and immediately tightly close the box or room. Allow this to stand forty minutes, then open. This formula suffices for 100 cubic feet of space. Should there be a larger or smaller amount of space to be covered, increase or decrease the formula proportionally. As, for instance, the room contained 500 cubic feet of space, then use five times the above formula; if 50 cubic feet, use one-half the formula. This particular formula applies only to nursery stock. In treating green-houses, a smaller amount of cyanide should be used, yet the principle of preparation is the same in all cases. *Hydrocyanic acid gas is deadly poisonous, thus the greatest care must be exercised in its use.*

INSECTICIDES AND FUNGICIDES COMBINED.

Bordeaux Mixture and Paris Green.

Copper sulfate	4 pounds.
Fresh stone lime	4 pounds.
Water	50 gallons.
Paris green	5 ounces.

Make the Bordeaux mixture as given on another page. Mix the green with water to form a paste, then stir into the Bordeaux. The green may be used in a larger amount than given in the above formula, but this is generally unnecessary.

By combining Bordeaux mixture with some arsenite, as Paris green, many fungous diseases and insect pests can be struck at the same time. This combination method saves a separate application of each substance, which would be necessary were the Bordeaux and arsenic compounds applied at separate times. Its range of usefulness is not exceeded by any of our spraying mixtures. Bordeaux mixture and Paris green can be applied together with perfect safety.

The other arsenious mixtures, as London purple, arsenate of lead, or arsenite of lime, may also be combined safely with Bordeaux mixture.

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SPRAYINC APPARATUS.

When the farmer, fruit grower, or gardener decides to spray, the first question that comes up is, what sort of spray pump and outfit he should obtain. To assist him in his selection, some of the types of spraying apparatus most commonly used will be given. It is hoped that, after a careful consideration of the different types of pumps herein given, he may be able to select the kind best suited to his own particular needs.

There are on the market many different kinds of spray pumps, which are manufactured by quite as many different concerns. Each particular kind of pump, whether it be bucket, knapsack, or barrel, has its own particular merits over each other kind. There is no "best" pump, for a pump that is satisfactory to one man might not be what another wants for his particular work. The pump that would be used to spray 10,000 fruit trees would not be the most suitable for using on 100 acres of potatoes, or in a small garden.

One requirement, however, should be made of all pumps purchased. The working parts, or the parts with which the spray liquid comes in contact, should be made of brass or some such metal which will not corrode. Iron will corrode when brought in contact with certain substances commonly present in some spray mixtures. It is important that neither leather nor rubber valves be used; only metal (preferably brass) which are ground to fit their seat perfectly. Valves other than metal will be constantly playing out.

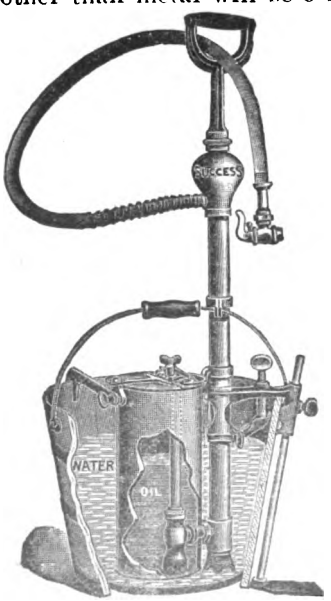

Fig. 1. Bucket Pump with tank for oil.

Bucket Pumps. These pumps are among the most durable of the simple force pumps in common use. The fact that they may be used in any ordinary sort of bucket, or pail, gives them an advantage over some of the other types of outfits. By the attachment of a foot-rest which extends outside the pail to the ground, the pump can be held very firmly. These pumps are suited for such use as in a garden, to spray the bushes in the yard, or a few small fruit trees. They cost from $3 to $7 complete, including rubber hose and a nozzle.

Air-pressure Sprayer. In this sort of apparatus the liquid is thrown out by the action of compressed air. After the tank is partly filled with the spray mixture and closed, air is pumped in which sets up a pressure on the liquid, thus forcing it out in the form of a fine spray.

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This sprayer has proven satisfactory with some people, and can be used in about the same field as the bucket pump. The Rochester Spray Pump Company and the E. C. Brown Co., both of Rochester, N. Y., make pumps of this sort, which cost from $4 to $7.

Fig. 2. Compressed-air Sprayer.

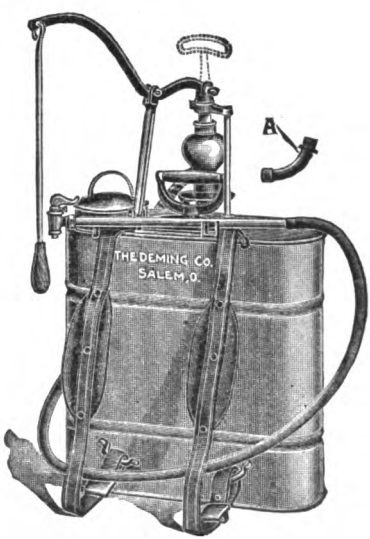

Fig. 3. Knapsack Pump, showing bent neck attachment at "A."

Knapsack Pumps. These pumps consist of a tank holding from three to five gallons, with straps so attached that the outfit can be carried upon the back in the same manner as a knapsack. The handle is so adjusted that it can be operated in front of the carrier. These pumps are put to their best advantage in spraying low-growing crops, such as strawberries, potatoes, or tobacco. They may also be used in spraying small trees. For general garden use, or for the man with a half-acre to an acre of truck crops, this pump is heartily

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recommended. In ordering, it is well to get a bent neck attachment as shown at (A), Fig. 3. This is needed in spraying the lower surface of leaves of low-growing plants. Price complete with hose and nozzle $10 to $20.

Barrel Pump. For general orchard work the barrel sprayer is the most important type. In this, the pump is adjusted to a barrel,

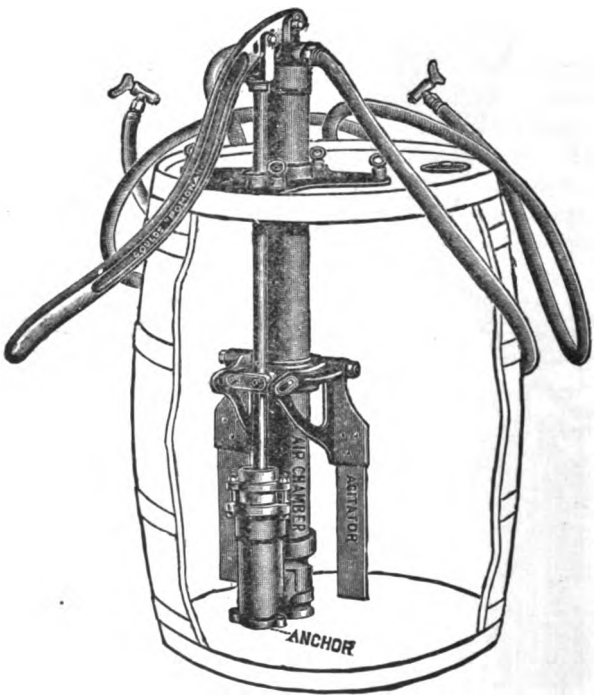

Fig. 4 Barrel Pump.

at either the side or end (preferably the side). In ordering this type of pump see that it is provided with a good agitator for keeping the spray mixture stirred while being used. The pump should be fitted so as to carry two leads of hose. Practically all manufacturers of spraying apparatus carry this type of pump. In our work we have found "The Spraymotor Jr., No. 2," made by the Spraymotor Co., of Buffalo, N. Y., entirely satisfactory. This particular pump, without hose or nozzle, costs $13 or $16.

Tank Sprayers. These differ from the barrel pumps mainly in their larger capacity and greater pressure. The "Planet," shown in Fig. 5, gives a general representation of the type. These pumps cost about $25.

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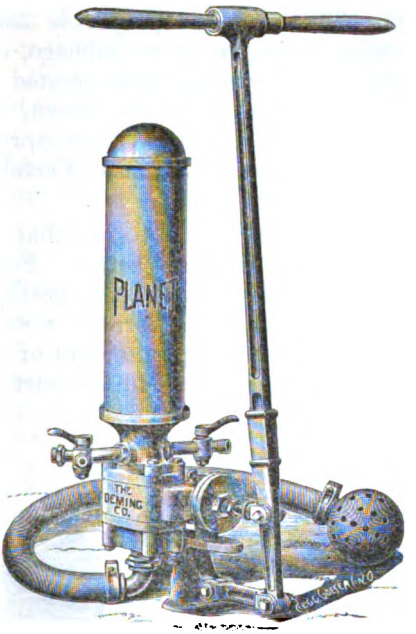

Fig. 5. Tank Sprayer.

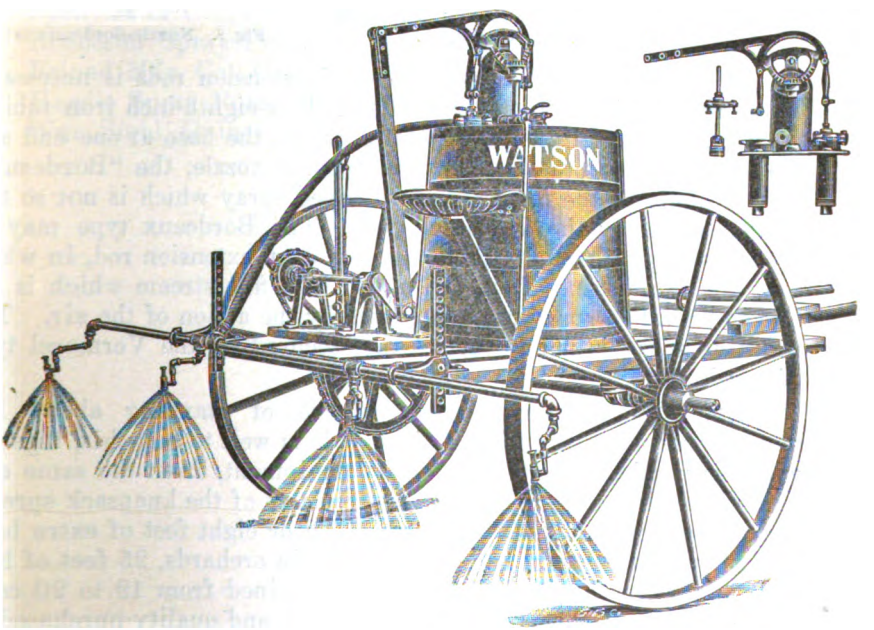

Fig. 6. Field Sprayer.

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Field Sprayer. This sort of sprayer is used in spraying low plants, such as strawberries, potatoes, cabbage, etc. Several nozzles are attached, so that as many rows can be treated at one time. Where a number of acres of truck crops are grown, this type of sprayer might be used to advantage. The "Watson Sprayer," shown in Fig. 6, can be bought of Mr. Percy L. Banks, Norfolk, Va., who is agent for the Danforth Company.

Nozzle. The nozzle used should be one that will throw the liquid into a very fine spray—the finer the better. For accomplishing this, the Vermorel type of nozzle has not been excelled. In this type the liquid issues from the nozzle in the form of a cone-shaped mist which can be made so fine when the proper amount of power is applied that the nozzle must be used quite close to the part sprayed. To secure

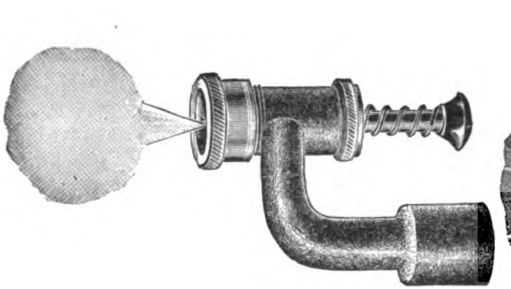

Fig. 7. Nozzle-Vermoral type.

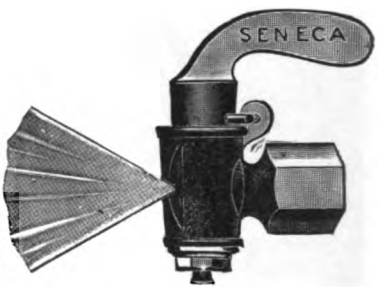

Fig. 8. Nozzle-Bordeaux type.

this in the case of tall trees the use of extension rods is necessary. These rods, which are usually made of three-eighth-inch iron tubing, from 6 to 12 feet in length, are attached to the hose at one end and the nozzle at the other. A second type of nozzle, the "Bordeaux," throws liquid in the form of a fan-shaped spray which is not so fine as that given by the Vermorel type. The Bordeaux type may be used to spray tall trees without the use of an extension rod, in which case the liquid issues from the nozzle in a fine stream which is not broken up into a spray until so caused by the action of the air. The resulting spray is not so fine as that secured by the Vermorel type of nozzle.

Hose. Good, durable hose, capable of standing about 125 pounds pressure, should be obtained. It is well to buy this, together with the nozzles and other necessary equipment, from the same concern where the pump is bought. In the case of the knapsack sprayer and bucket sprayer it is well to get seven or eight feet of extra hose. For use with the barrel and tank sprayer in orchards, 25 feet of hose is a satisfactory length. Hose can be obtained from 12 to 20 cents per foot, the price depending upon the kind and quality purchased.

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Care of Spraying Apparatus. When the spraying has been completed, do not let the sprayer stand without first having exercised some sort of care. Some spray mixtures are very corrosive in character and should not be allowed to remain in contact with the machinery after the work is done, any more than smoke should be allowed to remain in a gun after the bullet has been fired. When you have finished spraying, dump out the liquid which is left in the tank, and then throw in three or four pails of clear water. After forcing this through the pump, hose and nozzle, wipe off the exposed parts with a cloth. *The farmer should exercise as much care with his spraying outfit as a hunter would with his gun.*

Dealers. Before ordering a spray pump write for catalogues of several of the different concerns dealing in spraying machinery. Examine these different catalogues carefully, then select that pump you think best suited to your needs. The following concerns are reliable dealers in spraying machinery:

Gould Manufacturing Co., Seneca Falls, N. Y.
Field Force Pump Co., Elmira, N. Y.
Sydnor Pump and Well Co., Richmond, Va.
Morrell & Morley, Benton Harbor, Mich.
Deming Co., Salem, Ohio.
E. C. Brown Co., Rochester, N. Y.
Spraymotor Co., Buffalo, N. Y., and London, Canada.
Rochester Spray Pump Co., Rochester, N. Y.
Friend Mfg. Co., Gasport, N. Y.
Hardie Spray Pump Mfg. Co., Detroit, Mich.
Wm. Stahl, Quincy, Ill.

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EXAMPLES OF BENEFITS OF SPRAYING.

Spraying Protects the Foliage and Fruit from Insect and Fungous Attacks.—By properly spraying, perfect fruit and good yield are obtained where the omission of spraying would mean poor yield and diseased products, or permanent injury to the plant in the case of perennials.

A Marked Increase in Yield is often evident to even a casual observer. Where such is obtained by spraying there should be but little difficulty in securing recognition of the benefit from spraying.

Where the Increase in Yield is Slight, so slight as to require measuring to detect it, the benefit is often overlooked. Yet this slight benefit may turn a handsome profit upon the labor and materials invested in the spraying, and it is not to be ignored by the man who farms on business principles. To accurately judge the value of spraying, some portion of the crop should be left unsprayed, and the yield from sprayed and unsprayed fruits carefully noted and the differences compared with the cost of treatment. In the conduction of any large business every small increase in profit and every saving of leakage is important.

Perfection of Plant. The quality of the yield as well as the quantity is improved by spraying. Perfect fruit instead of imperfect fruit is harvested. With the prevalence of imperfect fruit on the market, the value of fruit of higher quality is often overlooked. The perfect product, however, proves its excellence on the market by its ready sale and the higher price it commands.

One cannot afford to raise inferior produce. The increase in quality, even if the quantity of the yield were not affected, is sufficient reason for spraying.

The Keeping Quality of many fruits grown for shipping manifests itself to the buyer and affects the price materially.

Protection of the Plant. In many cases the benefits are apparent the second and succeeding years rather than the first. Spraying protects the foliage that is accumulating nourishment for the crop the following year. If this foliage be protected from disease the crops of the future years receive the benefits. It is not only the yield of this year, but the future productivity of the plant that must be safe-guarded.

If a given plant or crop be raised for sale commercially, business principles demand that it be given that care which will give the greatest return for the money invested. It is now generally recognized by extensive growers of grapes, peaches, apples, potatoes, etc., that spraying pays. Spraying apparatus is as much a part of the equipment as is the plow, the harrow, or the knife. Spraying should be regarded

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as insurance. It insures the crop against the devastation of disease; yet it differs from insurance in most cases in the fact that it pays for itself year by year even if there be no general epidemic.

A few quotations from various sources to illustrate the benefit of spraying are appended.

The result from spraying potatoes in the New York Experiment Station is stated as follows:

"The increase in yield per acre due to seven sprayings was 123½ bushels, having a value of $61.75; allowing that the extra expense of the seven sprayings was $13.00 per acre, there is left a net profit of $48.75 per acre."

"*Cost of Spraying Potatoes.*—Bordeaux mixture as we use it costs about 0.8 cents per gallon. The aim is to apply from one hundred and fifty to two hundred gallons per acre; if two applications are made, about three hundred gallons are used, while three applications require about five hundred gallons."

Fairly thorough spraying of potatoes can often be done at an expense of one dollar per acre for each application. At this rate three sprayings would cost three dollars. The returns that may be expected from such sprayings would be twenty-five to one hundred bushels per acre increase in yield. In most seasons the increase in yield will cover the expense of spraying, and in many seasons there will be a large net profit.

From a grape experiment in Ohio we quote:

"The average selling price of the other grapes, including baskets, was about ten cents per basket; the average return accordingly was was $125.21 per acre. This enormously increased return was secured here at a cost of $7.50 per acre."—*Ohio Bull. 130, p. 33.*

"While the unsprayed area yielded seven hundred and ninety-two pounds, or ninety-nine baskets of eight pounds each of inferior wine grapes, equal sprayed areas yielded a little more than three hundred baskets of fine grapes which brought $30.50, including baskets.

"The return per acre from unsprayed area is calculated at 316 baskets per acre, worth less than $10.00 per acre, while from the sprayed areas the average yield was 1,252 baskets per acre, worth $125.20 per acre."—*Ohio Bulletin 130, p. 46.*

PEAR SCAB.

"In New York (Geneva) in one case spraying at a total cost of 55 cents per tree increased the average yield per tree from 45 cents to $6.55," a net profit of $6.10 per tree.

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APPLES.

"The sprayed portion yielded 534 sound apples or 4 bushels; and 48 wormy apples or about one-fourth bushel. The unsprayed portion yielded 216 sound apples or 1½ bushels; and 92 wormy apples or three-fourths bushel. Many wormy apples fell from the unsprayed portions during the season, and as this was not the case with the part sprayed, the above figures are very partial to the side that was not sprayed. The sprayed apples were larger, of better color, and showed less scab. The man who came to buy my crop saw the sprayed side of the tree first, and actually gave me five cents per barrel extra for all my fruit, although most of my orchard consisted of green instead of red apples."—*C. E. Chapman, Peruville, N. Y.; Bull. 60, Cornell Exp. Sta., p. 279.*

"Taking the average yield of the sprayed and unsprayed trees separately, we have the following results:

Northern Spy,	sprayed, average per tree.....	10.0	bu.
Baldwin,	sprayed, average per tree.....	8.5	bu.
Pearmain,	sprayed, average per tree.....	3.6	bu.
Baltimore,	sprayed, average per tree.....	7.0	bu.
Ohio Pippin,	sprayed, average per tree.....	6.6	bu.
Wells',	sprayed, average per tree.....	5.3	bu.
Grimes' Golden,	sprayed, average per tree.....	6.25	bu.
Northern Spy,	unsprayed, average per tree...	5.50	bu.
Baldwin,	unsprayed, average per tree...	3.25	bu.
Pearmin,	unsprayed, average per tree...	0.75	bu.
Baltimore,	unsprayed, average per tree...	3.5	bu.
Ohio Pippin,	unsprayed, average per tree...	0.5	bu.
Wells',	unsprayed, average per tree...	1.0	bu.
Grimes' Golden,	unsprayed, average per tree...	1.5	bu.

"The average per sprayed tree was 6.75 and of the unsprayed tree 2.42. Fifty sprayed trees produced 4.33 bushels of apples more per tree than the unsprayed, which was secured at a cost of not more than 20 cents per tree. In the case of the Northern Spy and the Baldwin, the actual profit derived from the treatment was more than five dollars per tree."—*Ohio Bull. No. 111, p. 114.*

"The following letter relates to the sale of apples from sprayed trees in Buffalo:

" 'The apples were as fine as anything I ever saw in the shape of Kings, even those rated as seconds or No. 2's being as good as the ordinary run of No. 1 fruit; in fact they sold at the price of other No. 1's. We commenced the trade on them as soon as they arrived

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here to some of our buyers of fancy fruit at $4.50 per bbl. in job lots. I think had we put the price at five dollars we should have gotten it; in fact, we did get it for a portion of them, while the ordinary run of King's and so-called No. 1's sold in single barrel lots at the same time at $3.75 to $4.00. We think they went out fully $1.00 per barrel better than the average run of King's, and all who had them were anxious for more.' "—*J. H. Gail, Bulletin 60, Crn. Exp. Sta., p. 277.*

"From the records it appears that where the trees (plum) were sprayed, the average yield per tree of picked fruit was increased 44 per cent, the marketable drops increased 8 per cent, and the waste decreased 81 per cent. The total yield of marketable fruit as recorded in pounds was 45 per cent greater where the trees were sprayed than where they were not sprayed."—*N. Y. Agr. Exp. Sta. 15th Annual Rep. P., 400.*

From experiments at Tryon we have "the average weight of good grapes obtained from a vine in the unsprayed rows was 1 pound 1.5 ounces, as compared to 4 pounds 5.8 ounces from those given six sprayings with normal Bordeaux mixture, a difference of 4 pounds 4.3 ounces to the vine, or over a ton to the acre. This gain of a ton or more of grapes to the acre was due entirely to the six sprayings, at a cost of $15.42. In addition to this increased yield, the grapes could be picked at less cost, the trimming could be almost done away with, and in the end a product of far better quality commanding a higher price was obtained."

COST OF MATERIALS.

The material necessary for making the fungicides mentioned in this bulletin may usually be purchased with ease. If, however, your local dealer does not handle them, they may be obtained from any wholesale drug dealer by mail order. To give some idea of the approximate price and to suggest the address of a few dealers from given. It is possible that even better rates can be secured by correspondence.

W. H. King, wholesale druggist, Raleigh, N. C.

Copper sulfate	$0.10 per lb.
Copper carbonate 5-lb. lots	.35 " "
Ammonia 26°	1.00 per gal.
Potassium sulfide, 10-lb. cans	.20 per lb.
Flowers of sulfur, small lots	.10 " "
Flowers of sulfur, large lots	.06 " "

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Formaldehyde solution 40 per cent, 5-pt. bottles, each	1.60	
Formaldehyde solution 40 per cent, 1-pt. bottles, each	.45	
Paris green	.25	per lb.
Pyrethrum	.25	" "
Whale-oil soap	.20	" "
Carbonate soda	.05	" "
Corrosive sublimate	1.25	" "
Crude carbolic acid	.40	per gal.
White arsenic	.20	per lb.
Arsenate soda	.30	" "
Acetate of lead	.25	" "
London purple	$0.25	per lb.
Commercial caustic soda, small lots	.10	" "
Commercial caustic soda, large lots	.08	" "
1-oz. bottle Formalin	.10	
2-oz. bottle Formalin	.15	
4-oz. bottle Formalin	.20	
8-oz. bottle Formalin	.30	
16-oz. bottle Formalin	.50	

W. H. KING DRUG CO.

Eimer & Armend, 205 to 211 3d Ave., New York City.

1 lb. copper sulfate	$0.10	
1 lb. copper carbonate	.35	
10 lbs. copper sulfate	.09	per lb.
1 lb. ammonia 26°	.15	
4 lbs. ammonia 26°, container extra	.12	per lb.
1 lb. commercial caustic soda	.15	
10 lbs. commercial caustic soda	.09	per lb.
1 lb. potassium sulfide, fused	.30	
10 lbs. potassium sulfide, fused	.25	per lb.
1 lb. flowers of sulfur	.10	
10 lbs. flowers of sulfur	.05	per lb.
1 lb. Formalin	.45	
10 lbs. Formalin	.40	per lb.
1 lb. Paris green	.20	
10 lbs. Paris green	.18	per lb.
1 lb. arsenate soda	.15	
10 lbs. arsenate soda	.12	per lb.
1 lb. acetate of lead	.15	
10 lbs. acetate of lead	.12	per lb.
1 lb. London purple	.20	
10 lbs. London purple	.18	per lb.
1 lb. Hellebore Po.	.25	
10 lbs. Hellebore Po.	.20	per lb.

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1 lb. Pyrethrum	.40	
10 lbs. Pyrethrum	.35	per lb.
1 lb. whale-oil soap	.12	
10 lbs. whale-oil soap	.10	per lb.
1 lb. commercial white arsenic	.15	
10 lbs. commercial white arsenic	.10	per lb.
1 lb. carbonate of soda (washing soda)	.02½	
1 lb. corrosive sublimate	.95	
10 lbs. corrosive sublimate	.90	per lb.
1 lb. crude carbolic acid	.10	
1 gallon crude carbolic acid	.50	

Merck & Company, University Place, New York City.

Copper sulfate, pure	$0.12	per lb.
Copper carbonate, pure	.35	" "
Ammonia 26°	.09	" "
Formaldehyde, in 1-lb. bottles	.35	" "
Sodium arsenate crystal	.17	" "

Arthur H. Thomas Co., S.W. Corner 12th and Walnut streets, Philadelphia, Pa.

	100 Lbs.	10 Lbs.
Copper sulfate	$7.00	$0.80
Copper carbonate	23.00	2.50
Commercial caustic soda (ground)	4.75	1.00
Potassium sulfate (ground)	8.00	1.00
Flowers of sulfur	4.00	.50
Formaldehyde 40 per cent, in carboys	19.95	2.00
Paris green	25.00	3.00
Arsenate of soda	18.00	2.00
Acetate of lead	13.00	1.50
Commercial white arsenic	7.00	.90
Carbonate of soda	2.50	.30
Corrosive sublimate	85.00	9.00
Whale-oil soap, 275 lbs.	14.00	1.60

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Bulletin No. 194. **June, 1906.**

NORTH CAROLINA

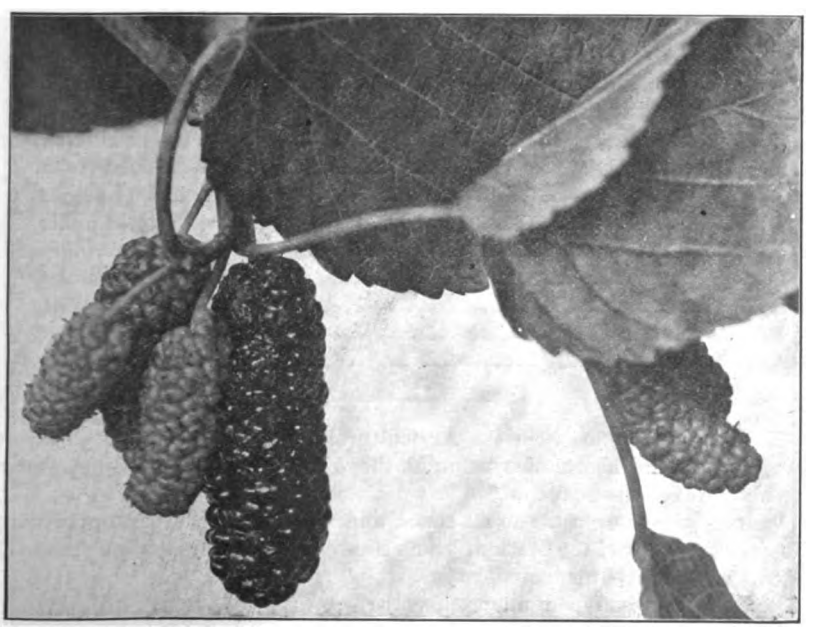
Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts

RALEIGH

MULBERRIES.



THE NEW AMERICAN MULBERRY.

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N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

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O. L. BAGLEY ..... Assistant Chemist.
R. H. HARPER ..... Assistant Chemist.
F. C. REIMER ..... Assistant Horticulturist.
A. F. BOWEN ..... Bursar.

The Director's office is in the Agricultural Building, Raleigh: the experiment grounds and laboratories being at the Agricultural College, just west of town and on the street car line.

Visitors will be welcome at all times, and will be given every opportunity to inspect the work of the Station. Bulletins and Reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

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MULBERRIES.

BY H. HAROLD HUME AND F. C. REIMER.

INTRODUCTION.

Probably no fruit of equal importance from many standpoints, grown in America, has received so little attention from plant improvers and planters as the mulberry. Found here and there throughout the country in fence-corners and neglected spots, in poor uncultivated soil, it is true that the mulberry has had little opportunity to show the intrinsic merits which it unquestionably possesses. It is deserving of more and better attention than it has received heretofore, though it is doubtful whether it possesses any of the essential characteristics necessary to give it standing as a market fruit. With us any fruit which is not valuable for market purposes is likely to receive scant consideration. But on the other hand we must not lose sight of the fact that the mulberry can be grown easily, that it bears fruit profusely for a long period each year, and these points, coupled with the fact that it can be put to a goodly number of domestic uses, make it particularly valuable as a home or farmyard tree.

It thrives in all parts of North Carolina, and though we are not ready to recommend its extensive planting, still we do believe that every farm home should have a small number of trees.

Within recent years some attention has been given to the subject of silk culture,* and it is hoped and believed by some that eventually something in the way of a silk industry may be developed in this country. However that may be, we must not lose sight of the fact that in the development of any such industry, the primary requisite is the presence of a sufficient number of trees of the proper sort (Morus alba) within convenient reach from which to procure the necessary leaves for feeding the silk worms.

PROPAGATION.

The mulberry may be propagated from seeds or by grafting, budding, layers and cuttings. Of these methods the most important ones are by means of seeds, by grafting and by cuttings. These are the only ones which we deem it necessary to discuss, with the possible exception of sprig budding, which is in reality a method of grafting.

SEED PROPAGATION.

The mulberry can be easily propagated by seed. This method is used largely in propagating the mulberry when the tree is used for

*Those interested in this subject should procure a copy of Bulletin 181, N. C. Experiment Station, by Gerald McCarthy.

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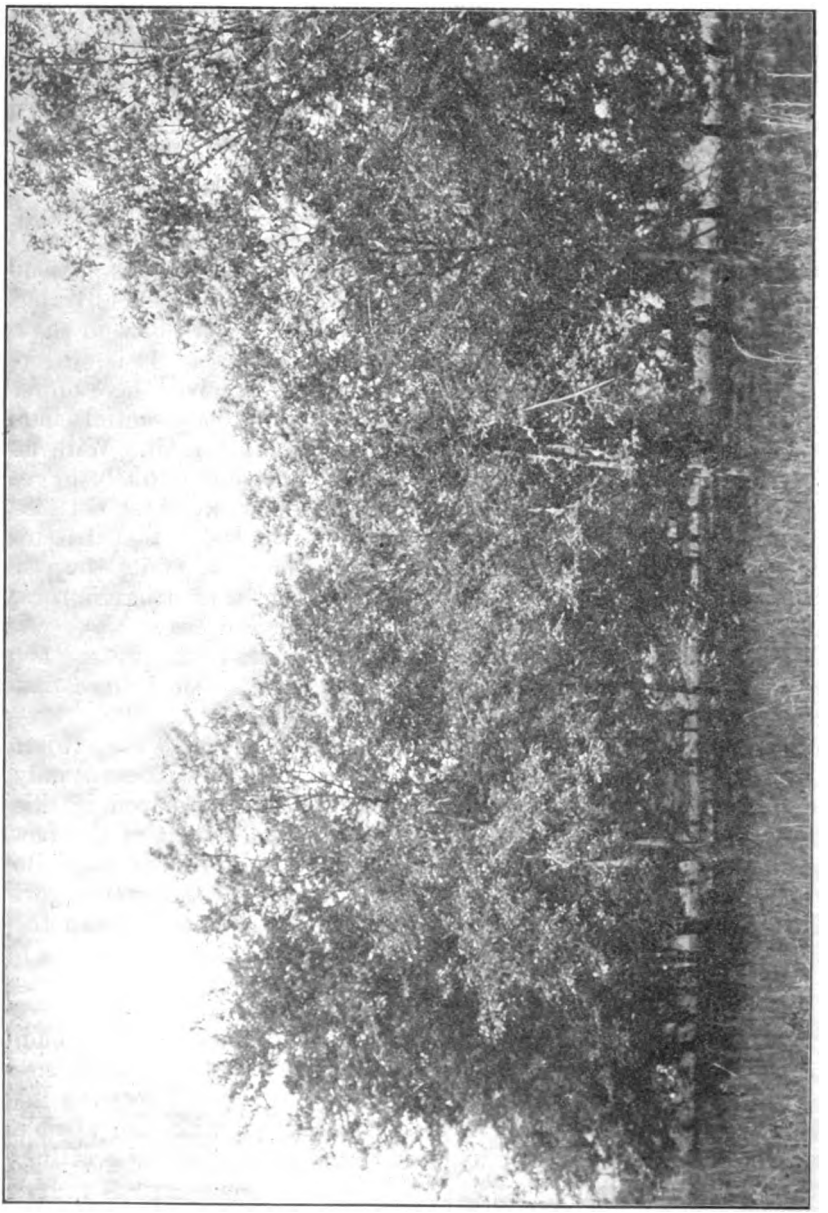

GROVE OF BLACK ENGLISH MULBERRIES, RALEIGH, N. C.

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feeding silk worms in the silk industry. For this purpose the method does very well, as it is not important whether the seedling trees resemble the parent plant closely or not. Trees desired for hedges and ornamental purposes may also be grown in the same way, but when fruit is desired the best and most desirable kinds cannot be secured from seedling trees.

When gathering fruit to secure the seed, the best plan is to spread a large sheet under the tree and shake the fruit down upon it. The fruit should be mixed with a sufficient amount of water in a large tub or vat and thoroughly stirred so as to separate the seeds from the pulp. Running water should be provided if possible. Introduce the stream at one corner of the vat and allow it to flow through the box and out at the lower side, carrying with it the pulpy material as it is separated from the seed. The seed should then be dried and planted immediately or kept for future use. Seeds taken from early fruit may be planted at once. If seeds are to be held for planting the following spring, they should be thoroughly dried before storing, and kept in a cool, dry place.

Sowing the Seed.—The preparation of the land for mulberry seeds should be thorough. The ground should be well pulverized, mellow, deeply broken and sufficiently rich to give the seedlings a good start. It should contain a goodly quantity of vegetable matter to enable it to hold the necessary quantity of moisture. This needed vegetable matter may be secured by dressing the land with stable manure or by plowing under a crop of cowpeas or some other legume.

The rows should be laid off three and a half or four feet apart. Sow the seed thinly about two or two and a half inches deep. This work may be done by hand or a garden seed-drill may be used for the purpose.

In North Carolina, generally speaking, the seed may be sown between the latter part of March and the latter part of May. Seed that has been held over from the previous season will not germinate so rapidly as the newly-extracted seed, and for this reason should be planted as early as possible. Taking the State as a whole, the best date would be about April 15th. Seed freshly extracted cannot be secured until the middle of May, but may be sown then with good results, provided the weather conditons are right.

PROPAGATION BY CUTTINGS.

Most species of mulberries are easily propagated by means of cuttings. And while the most satisfactory and most economical plan is to use one-year-old branches for this work, twigs of the current season's growth may also be used.

Cutting wood may be removed from the trees soon after the leaves have dropped. Select well-matured, well-developed one-year-old

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branches from one quarter to five-eighths inches in diameter. Cut these into pieces, each being provided with from three to six good buds. The length of the pieces will vary somewhat, from eight to ten inches is about right, but before planting it is best to divide them into bunches, each bunch being composed of those of nearly equal length. The upper cut should be made a half inch above a bud, and a very sharp knife should be used to insure a perfectly smooth cut. Smooth cuts will callus over much more rapidly than ragged ones. Before planting, it is sometimes desirable to split the lower ends of the cuttings an inch or two and spread them slightly, thus giving a larger surface to callus over. This often results in a much stronger root system and consequently more vigorous growth during the season.

In eastern North Carolina the cuttings may be planted immediately after removal from the trees; but in the colder sections it is usually best to tie them together in bunches of twenty-five and store them in damp sand in a cellar or pit until spring. The bundles should be entirely buried, and by spring it will be found that the wounds have callused, and in some cases tiny roots will have started. A good plan for storing is to pack them on end in sand, covering them about half way up and then covering over the tops with damp sphagnum moss.

The ground in which the cuttings are to be set should be well plowed and pulverized thoroughly, then rolled. The earth, if in good mechanical condition, may be opened for the cuttings by simply thrusting a spade down into it, along the line from one end of the area to the other, at each thrust shoving the spade a little to one side to make an opening. Into the opening thus made thrust the lower ends of the cuttings, leaving only one bud above the surface, and pack the earth tightly back in place with the feet. Or, a furrow may be thrown out with a plow and the cuttings covered up to the top bud by plowing a second furrow back against them, packing the earth against them as already indicated. Planting should be followed with a cultivation with a light cultivator to provide a surface mulch of dry earth.

PROPAGATION BY BUDDING AND GRAFTING.

Mulberry trees cannot be propagated as cheaply by budding and grafting as by seeds and cuttings, but seeds will not give trees like those from which the seed was gathered, and cuttings will not make large-sized trees quickly enough in many cases. Hence, to get good-sized trees in a comparatively short time and of known parentage, budding or grafting must be done. The common methods used in propagating the mulberry are sprig or scion-budding and whip, cleft and saddle-grafting. All the methods of grafting mentioned may be

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used indoors, *i. e.*, bench-grafting; while the first two, viz., whip and cleft-grafting, are the only ones which can be conveniently used for outdoor work.

STOCKS.

In the North and West, Russian mulberry seedlings are used for stocks, while by many Southern nurserymen *Multicaulis* mulberry stem or root cuttings are used almost entirely. Whether Russian mulberry seedlings would or would not be superior to *Multicaulis* cuttings or seedlings, we are unable to say, as experimental knowledge is lacking on this point; but in the longer-growing season of the South it is a fact that in some parts the trees, even when grown on root cuttings, reach such a size in a single season as to make them unsalable. Under such conditions they should be grown only from cuttings.

WAXES AND WAXED CLOTH.

Grafting Wax.—Good grafting wax may be made from resin, beeswax and tallow or linseed oil. A large number of formulas have been used, but the following are good and may be taken as representative:

1. Resin, 6 pounds; beeswax, 2 pounds; linseed oil, 1 pint.
2. Resin, 4 pounds; beeswax, 2 pounds; tallow, 1 pound.

Melt the ingredients of either formula in an iron kettle over a slow fire. Stir as they melt, to insure thorough mixing. Pour out into a bucket of cold water, grease the hands and pull until it becomes straw-colored. Wax not intended for immediate use may be rolled up in greased paper and put away. Grease the hands a little in using the wax.

Waxed Cloth.—Melt a sufficient amount of the wax in a kettle. Into it dip narrow sheets of old calico or cambric. As soon as saturated with the wax take them out, stretch and allow to cool. For use tear into strips about one-half inch wide.

Waxed Twine.—Melt the wax as above, and into it drop balls of No. 18 knitting cotton. Stir them about in the wax for about five minutes, by which time the wax will have penetrated them. Then take them out and allow them to cool. The twine will break easily without injuring the fingers.

SPRIG BUDDING.

This method may be used in propagating the mulberry. It was probably first extensively used by S. D. Willard, Geneva, N. Y.

The scions should be cut in autumn as in the making of cuttings, and held over until time for inserting in spring after the leaves have

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started, and the bark separates readily from the wood. Use small-sized, well-matured shoots with two or three well-developed buds. Prepare the scions for inserting in the stocks by making a smooth, sloping cut on the lower end. This cut should be an inch or an inch and a quarter in length.

The stock is prepared for the scion as in ordinary shield-budding by making two cuts in the shape of the letter T on its side, close to the ground where the scion is to be inserted. Carefully lift the edge back and insert the scion, shoving it well down into place. Then wrap with waxed cloth or twine and cover the point of union with grafting wax.

In from ten days to two weeks the parts will have united, provided the operation is successful. At this time the stock should be lopped or its top should be cut back to divert a larger portion of the sap to the scion, thus forcing it into growth.

WHIP GRAFTING.

For this work either a whole seedling root or a piece of a root may be used as a stock. On account of the spongy nature of the mulberry root it is best to use the whole root, making the insertion at or in the solid part of the stem just at the ground. In the warmer parts of the State the stocks may be taken from the ground as desired for use, but in the colder sections, where the ground is more or less frozen during winter, they should be lifted in autumn after they have become dormant and stored until needed in February and March. The scions should be procured about the same time and carefully stored.

In preparing the stock cut off the tops and at the crown or on the root at the desired point, as the case may be, make a sloping cut one and a quarter inches long. On the scion (cut to a length of six or eight inches with a bud within a half inch of the upper end) make a corresponding oblique cut. On both stock and scion raise a tongue of wood and then shove the two pieces together, taking care that the cambium layers along one side at least are in contact. Then wrap with waxed cloth.

In eastern North Carolina these may be planted out immediately, but in the western sections it is best to tie them in bundles of twenty-five, and store as directed for cuttings, until time for planting arrives.

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CLEFT AND SADDLE GRAFTING.

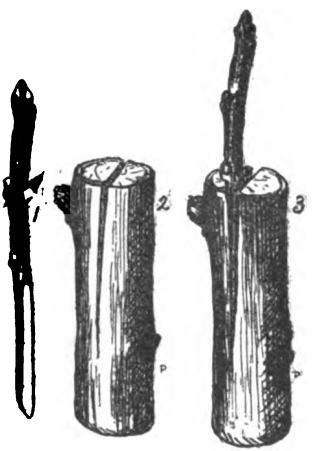
SADDLE GRAFT.
(From author's Bulletin for January, 1906.)

Both these methods are well adapted for the propagation of the mulberry, and may be used either for whole stocks or for piece roots, or stem-cuttings.

The scions and stocks should be procured in late autumn and stored until February, as directed under whip grafting.

Cut the scions six or eight inches in length. For cleft grafting, trim the lower ends to a wedge, with sloping cuts one inch in length, and for saddle grafting split the scions one inch up from the lower end.

Prepare the stocks for cleft grafting by splitting them down one inch, and for saddle grafting by trimming to



CLEFT GRAFT.
(From author's Bulletin of Department of Agriculture, January, 1906.)

a wedge to fit the split ends of the scions. In both methods place the stocks and scions together with the cambium layers in contact, wrap and treat as directed under whip grafting.

SOILS.

No tree will thrive on a greater variety of soils than the mulberry. In fact, it seems to be indifferent as to the kind of soil. In North Carolina it can be grown successfully on the sandy soils of the coast

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region, the sand hill section, the heavy clays of the Piedmont, and the clays and rocky soils of the mountains. The soil need not be rich, must not be too wet, but should be rather moist. It flourishes best on the moist, sandy loams of the eastern part of the State.

PLANTING.

The planting can be done either in fall or spring. In Western North Carolina the best time for planting is during the month of March, while in the eastern sections late November to January is probably the best season. The distance apart should be varied for the different kinds. Large trees—like New American, White English and Black English—should be planted not less than thirty feet apart; and those belonging to the American species (*M. rubra*)—like Stubbs and Hicks, should be planted thirty-five feet apart. The varieties belonging to the Russian group are usually smaller and need not be planted more than from twenty to thirty feet apart.

The planting does not require any special skill or care. The trees will usually live even under the most adverse conditions. Dig the hole large enough to receive the roots, and deep enough so that the tree will stand slightly deeper than it did in the nursery row. As nursery trees are usually large they should be heavily cut back; say to a height of three feet. The long roots are much broken in digging the trees, and should be well trimmed before setting.

CULTIVATION.

The mulberry needs little or no cultivation. When planted in chicken yards or where hogs are allowed to run and root, no extra cultivation need be given. They will thrive in soddy land; but generally the trees do better where the soil is stirred or worked, as in hog pastures. If any cultivation is given it should be shallow, as the roots spread out near the surface of the ground. Deep plowing should not be practiced.

PRUNING.

The mulberry requires little or no pruning. But as the wood is rather brittle and the branches are easily broken by sleet storms, the stubs which are left should be cut off close up to the trunk and the broken branches cut smoothly off at the ends; all large wounds should be covered with paint. The Black English variety has a tendency to grow tall and upright; this can be overcome by cutting it back while the tree is young. Some varieties form very thick heads, which could be thinned out to advantage. Long roots should be cut back when planting.

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VARIETIES.

The number of varieties of mulberries brought forward is not large. Of these a number have been added quite recently, and it is very probable that the list will be increased from year to year. Most of these are seedlings which have attracted attention in different regions because of merits which they possess. Undoubtedly there are many varieties in the country not now advertised or propagated by nurserymen which are equal or superior to many of our named varieties. This is but a natural result of the planting of a large number of seedling trees.

The nomenclature of the mulberries is badly mixed, and it is impossible to trace some of the varieties back to their origin.

We have endeavored to classify all the varieties now catalogued or grown in the South, according to the species from which they have been derived. This system of classification was first used by Professor L. H. Bailey.

In one or two instances it has been very difficult to say in which group a certain variety belongs. In some instances they appear to grade into each other in such a way as to suggest a hybrid origin. This is particularly true of the Black English now grown in North Carolina. We have placed it in the Morus alba group, but it shows some characteristics of our native mulberry Morus rubra, and it is in all probability a cross between the two species just named.

In planting mulberries for fruit in this State the following varieties should be given preference:

Black-fruited: New American, Black English, Stubbs and Townsend. White-fruited: White English and White Russian.

The New American is a large-fruited, prolific variety. The fruit is sub-acid and of excellent quality.

Black English is a strong upright grower, which bears a large amount of fruit of medium size for a long period. This is one of the most satisfactory varieties catalogued by North Carolina nurserymen.

Stubbs. This is a wide-spreading, vigorous, large-fruited and prolific variety. The fruit is strongly sub-acid, and the largest variety known to the writers.

Townsend. This is probably the earliest fruiting variety now grown. While it has not been grown in this State, we believe that it should be introduced. It would lengthen the mulberry season considerably.

White English. It is a very heavy bearer, producing sweet, medium-sized fruit for many weeks. This is by far the best white-fruited mulberry that we have seen.

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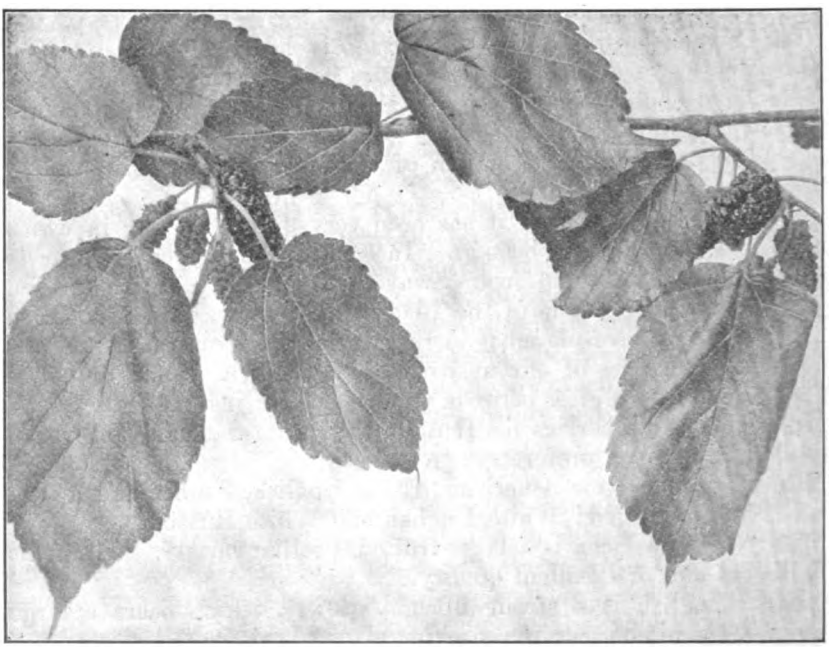

BLACK ENGLISH (ONE-HALF SIZE).

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DESCRIPTION OF VARIETIES.

Varieties Derived from *Morus alba.*

This species is probably a native of China, and has been cultivated for centuries in the Old World for feeding silk worms. It was introduced into this country early in the last century and now is often found wild throughout a large portion of the eastern part of the United States.

The tree is a large, vigorous, upright grower, with medium-sized, ovate or oblong leaves which have a smooth, shiny surface and are light green in color. The teeth on the margin are usually large and rounded.

The fruit of the original form of this species is white or violet; but a number of black-fruited varieties have also been produced.

Black English. Fruit—Form oblong, slightly curved; medium to large, ¾ x ⅜ to ¾ x ½ inch; reddish, becoming black when fully ripe; apex rounded; base oblique and irregular; stem ½ inch long, slender; druplets variable, flat to circular in outline, compacted and firm; sutures rather shallow and narrow, flavor sweetish; quality only fair. Season, May to July.

Leaves—Ovate to oblong elliptical, regular; apex long acuminate; base rounded or slightly cordate or nearly truncate; leaves on young growth four to five lobed, sinuses deep and rounded; size variable, average 3¼ x 2½ inches; surface smooth above, rough beneath, finely pubescent along the veins; color dull green above and light green below; margin regular, strongly serrate, sometimes serrate dentate; petiole 1 to 1½ inches, stout, veins prominent, white; pubescence well marked on veins and very fine over entire under surface.

Tree—Large, vigorous grower; strongly upright in habit, branches with a stripped habit; heavy and continuous bearer. Much grown in North Carolina. Specimens obtained from J. Van Lindley, Pomona, N. C.

New American. Fruit—Form oblong, slightly curved and somewhat irregular in large specimens. Size, very large—1½ x ½ to 1¾ x 8-16 inch; color, shining black when ripe; apex blunt and rounded; base oblique and irregular; stem stout and short, ⅜ inch; druplets medium in size, flattened, irregular, compact, smooth; sutures rather shallow and narrow; flavor very sweet; quality good. Season, May to July.

Leaves—Ovate to oblong, often somewhat rhombic on young growth. The leaves are two to four lobed, sinuses rather shallow and acute; apex long acuminate; base truncate; size 2 x 1½ to 4¼ x 2½ inches; thick, leathery, smooth upper surface, lower surface slightly rough; color dark green, shiny; margin serrate dentate, teeth rounded; veins prominent, whitish, no pubescence.

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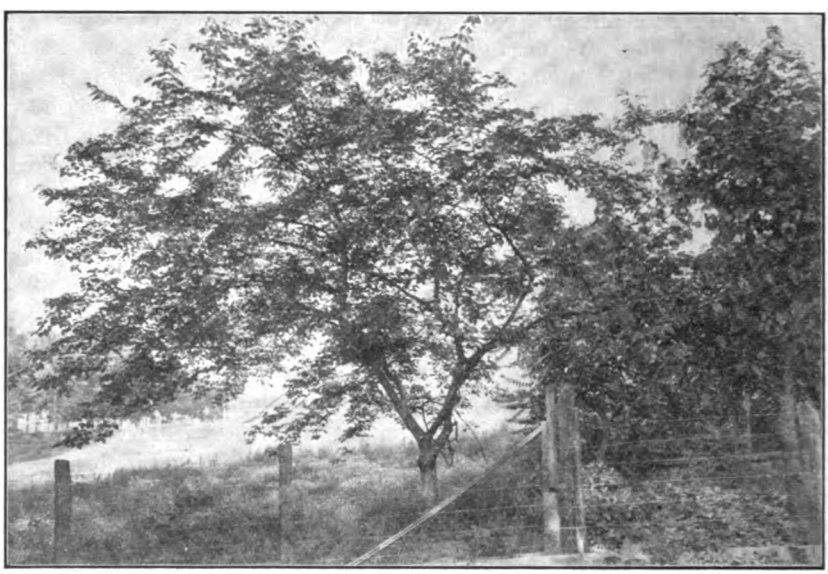
Tree—A large, vigorous, hardy tree. A heavy and continuous bearer. Introduced about 1854 by N. H. Lindley, of Bridgeport, Conn. Very widely grown and considered the best variety now in cultivation. Specimens received from J. Van Lindley, Pomona, N. C. Especially adapted to the cold mountain climate.

Westbrook (Westbrook Choice) (*Black English*). Fruit—Form oblong, slightly curved; size medium—¾ x 5-16 to 13-16 x ⅜ inch; color reddish, becoming black; apex rounded; base oblique; stem short, 5-16 to ⅜ inch, slender; druplets variable, oblong to roundish in outline, loosely compacted; sutures of medium depth and rather narrow; flavor sweet, pleasant; quality good. Season, May to July.

Leaves—Shape oblong, pointed; apex long acuminate, base truncate or slightly cordate; rather small—1½ x 1½ to 4 x 2 inches; aver-



WESTBROOK (BLACK ENGLISH).

age 3 x 2 inches; character thin, smooth above, slightly rough beneath; pubescent on larger veins; color shining, light green above, light yellowish green beneath; margin serrate, well marked, regular; petiole short, ¾ inch, medium stout; veins prominent, whitish, pubescent on large veins.

Tree—Of medium size and vigor, heavy fruiter. This is simply a selected strain of Black English. A good variety for poultry and swine. Much like Black English. Specimens obtained from J. Van Lindley, Pomona, N. C.

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White English. Fruit—Form oblong, curved; size medium—$\frac{5}{8}$ x $\frac{3}{8}$ to 13-16 x 7-16 inch; color whitish, turning brownish as it becomes over-ripe; apex rounded, base rounded or oblique; stem long, $\frac{1}{2}$ to $\frac{5}{8}$ inch, slender, curved; druplets flattened, narrow, compacted, medium in size; styles very prominent on ripe fruit; sutures narrow and fairly deep; flavor sweet; of good quality. Season, May to July.

WHITE ENGLISH.

Leaves—Oblong, elliptical, some leaves nearly rhombic, young leaves two to five lobed, sinuses shallow and rounded; apex with long acuminate point; base slightly cordate; average size $3\frac{1}{2}$ x 2 inches; medium, thick, upper surface smooth, lower surface smooth and somewhat pubescent; upper surface dark green; lower surface yellowish green; margin strongly serrate, dentate; petiole short, slightly curved; veins very prominent on lower side, whitish; pubescent only in the axils of veins.

Tree—With a distinct spreading, sprawling habit. Very vigorous. Bark on larger branches with distinct brownish, irregular, cracked streaks. The fruit is very sweet and pleasant. Specimens for description obtained from J. Van Lindley, Pomona, N. C.

Varieties Derived from *Morus alba var Tartarica.*

This is a sub-species of the White Mulberry group. It was introduced into the West by Russian Mennonites about 1875, and has

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proved itself well adapted to that rigorous climate; it is undoubtedly our hardiest mulberry. As it is usually propagated from seed, it is very variable.

The tree is small and bushy, usually with a drooping habit. It is much used as a stock where extreme hardiness is necessary. The fruit, like that of its parent, the White Mulberry, is variable in color and size. Most varieties of it are white or violet in color and more rounded in form than those of other species. Some forms of it are much used for ornamental purposes.

Abundance. Same as Barnes.

Barnes. Fruit—Cylindrical, somewhat curved; size medium—$\frac{3}{4}$ x $\frac{3}{8}$ to 1 x $\frac{1}{2}$ inch; color black, when fully ripe; apex rounded; base irregular and oblique; druplets large, ovate to roundish in outline, compact; styles present but not conspicuous; sutures shallow and narrow; stem short and thin, and deeply imbedded; flavor slightly sub-acid, but very sweet when fully ripe; quality fair. Season, May and June.

Leaves—Ovate to oblong ovate; apex rounded or sometimes acute; base truncate, often oblique; size medium—$2\frac{1}{2}$ x $1\frac{3}{4}$ inches; thin and smooth; dark green in color; margin serrate-dentate; veins distinct but not prominent.

This variety was introduced about ten years ago by John Frasier, of Huntsville, Ala., who secured it from a neighbor as a Russian seedling. It has also been advertised recently under the name "Abundance."

Black Russian (*Russian*). Fruit—Short oval to oblong; size medium—$\frac{3}{4}$ x $\frac{1}{2}$ to 1 x $\frac{1}{2}$ inches; black when ripe; apex blunt, obtuse; base oblique, somewhat irregular; stem short, small—$\frac{1}{4}$ to $\frac{3}{8}$ inch long; druplets large, broad and rounded, irregular, rather compact; sutures deep and open; flavor sweet, slightly sub-acid; quality good. Season, May to June.

Leaves—Ovate, often oblong-ovate; size medium—$3\frac{1}{4}$ x 2 to $4\frac{1}{2}$ x 3 inches; thin, leathery, smooth above, rough below; dark green in color; margin irregular, singly or doubly dentate-serrate, teeth large and rounded; young leaves strongly lobed; veins prominent, whitish; and rounded; young leaves strongly lobed; veins prominent, whitish; pubescent along veins on under side.

Tree—Small, rapid grower, hardy. Early and heavy bearer. One of the many Russian seedlings. Obtained from John Young, Greensboro, N. C.

The three following varieties are not grown in the State so far as we know, and have not been seen by the writers. We do not know what class the Monark belongs to, but have placed it here because

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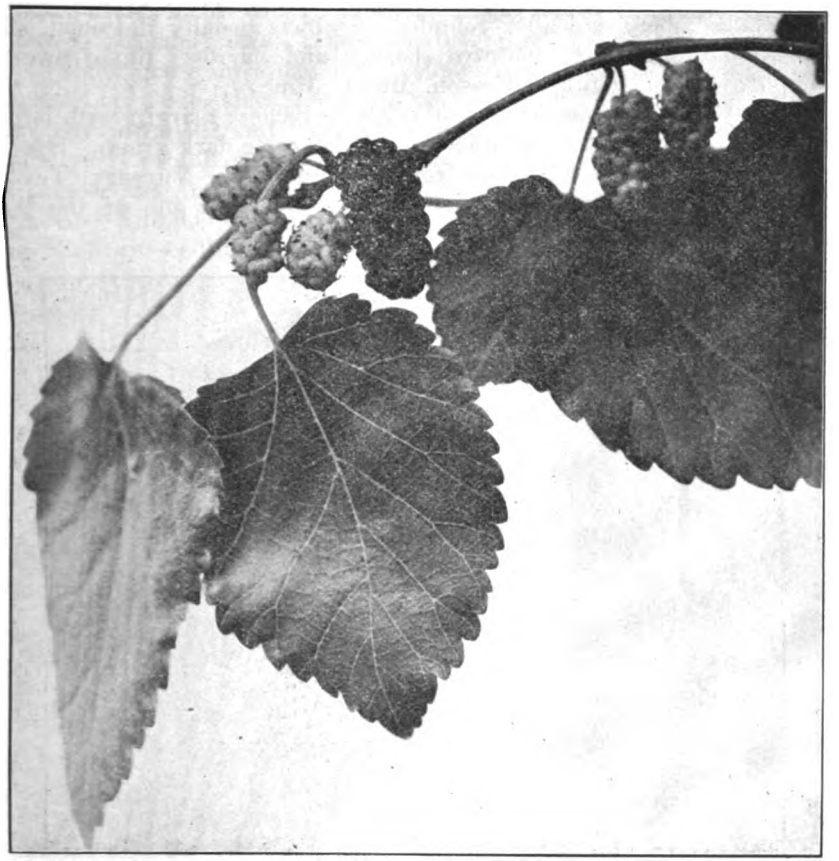

BLACK RUSSIAN.

it originated in that part of the West from which most of our Russian varieties have come.

Monarch. This is a white-fruited variety, advertised by Stark Bros., Louisiana, Mo., who secured it from Mr. E. H. Riehl, of North Alton, Ill. A chance seedling which came up at Mr. Riehl's place about forty years ago. It is said to be a very vigorous grower. The original tree is said to be over 60 feet high, with trunk over nine feet in diameter.

Munson. Originated by T. V. Munson, of Denison, Texas, from a seedling of the Russian. Said to be one of the best Russians.

Ramsey. A white-fruited mulberry of Russian parentage. Not highly prized. Introduced about 1880 by Ramsey & Son, of Mohamet, Texas.

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Victoria. Fruit oblong or cylindrical; size small—7-10 x $\frac{3}{8}$ inch; color black; base and apex rounded; druplets usually flattened, oblong, medium in size; sutures shallow and narrow; flavor sweet, insipid; of poor quality. Season, May to June.

Leaves—Ovate, lopsided; small—2 x $1\frac{1}{2}$ inches; margin with large rounded teeth; surface smooth; thin blade; color dark green. Specimens for description obtained from G. Onderdonk, Nursery, Texas. Introduced by G. Onderdonk in 1883. Said to be one of the best varieties in Texas.

WHITE RUSSIAN.

White Russian. Fruit—Form variable, from oval to oblong, plump; medium in size—$\frac{3}{4}$ x $\frac{5}{8}$ inch; color white, and ends of druplets purplish, becoming deep purple when over-ripe; base and apex rounded and regular; stem medium, stout and long, 7-16 inch, curved; druplets large oval or roundish in shape, loosely compacted; sutures deep and open; flavor very sweet and rather flat; quality fair. Season, May to June.

Leaves—Ovate to oblong, usually lopsided, leaves on young growth

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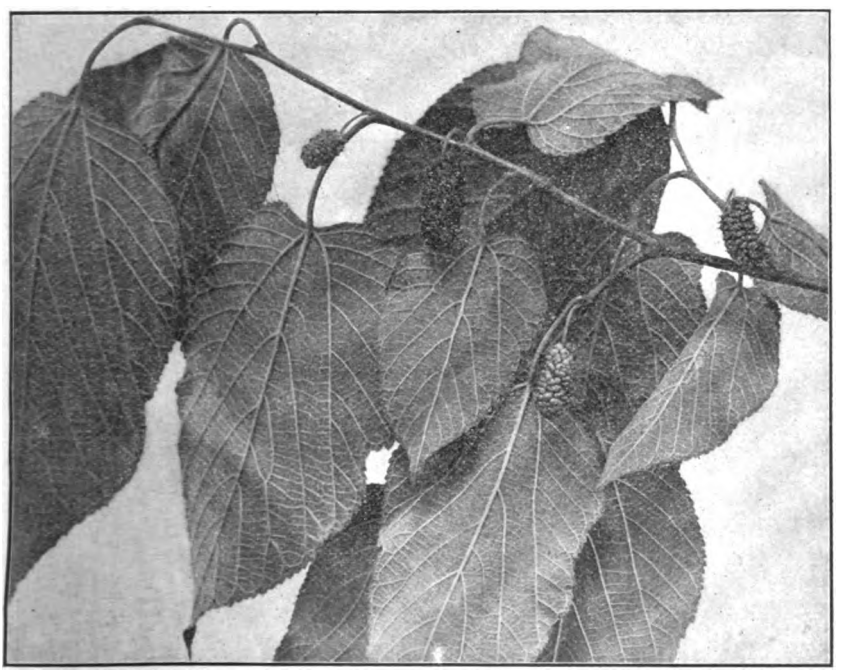
deeply three to five-lobed; apex short—obtuse or rounded; base obliquely truncate; blade rather small—$1\frac{1}{2}$ x $1\frac{3}{8}$ to $3\frac{1}{2}$ x $2\frac{1}{2}$ inches; color dark green on upper side, yellowish green on lower side; thin, smooth on both sides; margin prominently serrate-dentate, teeth strongly rounded; and short; petiole $1\frac{1}{2}$ to $2\frac{1}{4}$ inches, stout, curved; veins very prominent on under side; whitish yellow in color; tufts of pubescence in axils of veins on lower side.

Tree—Small, bushy and very hardy; quite productive. One of the Russian seedlings from Kansas. Will probably become a desirable new variety. Specimens obtained from J. Van Lindley, Pomona, N. C.



NATIVE RED MULBERRY.

Varieties Derived from *Morus rubra*.

This species is a native of this country, and is very widely distributed, being abundant from the extreme north to the Gulf of Mexico. It is a very hardy and vigorous tree, and from it several important varieties have sprung.

Its leaves are large and rough, and those on vigorous shoots are usually much-lobed. The fruit varies considerably, but usually is reddish or black in color and of good, sub-acid flavor. On the wild forms the fruit is usually of medium size, but some of the varieties which have sprung from it have very large fruit of good quality.

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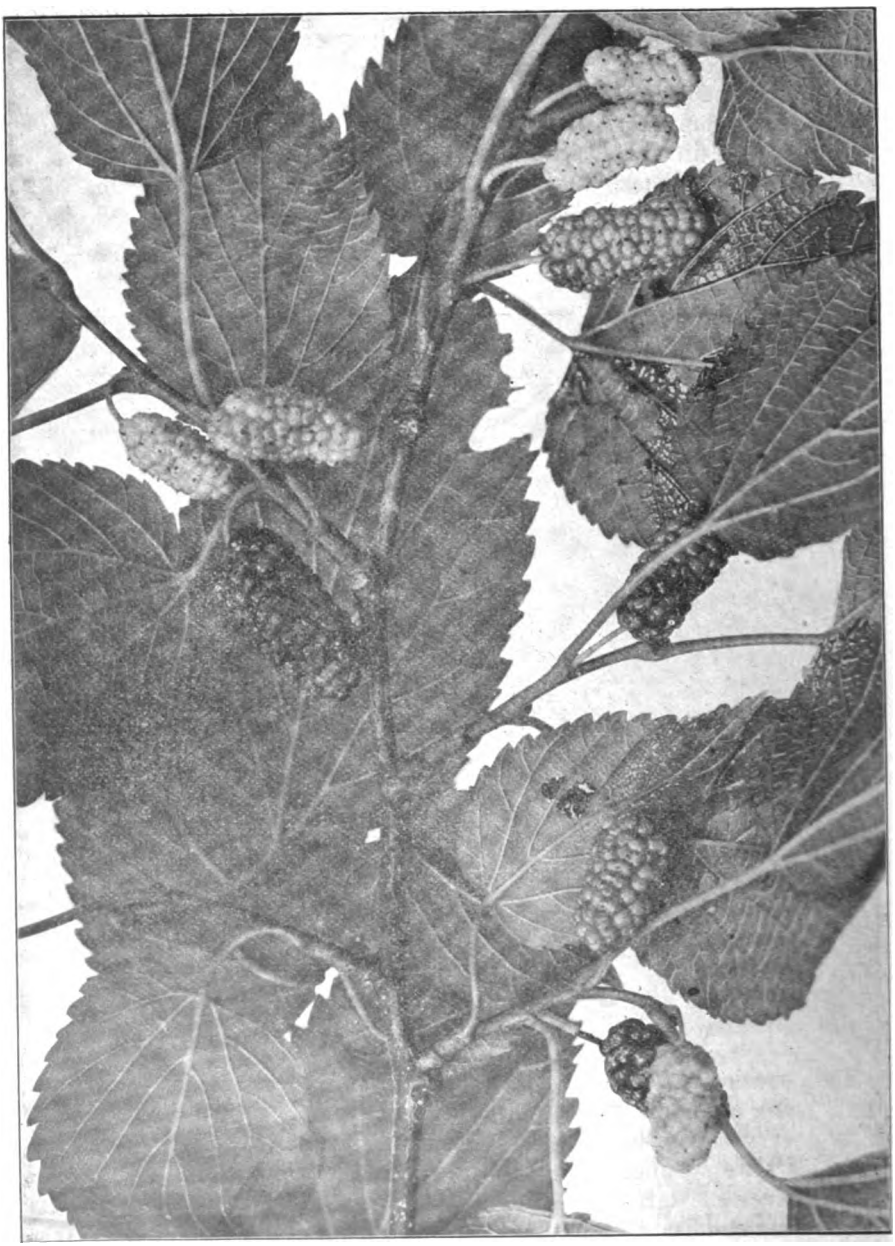

HICKS.

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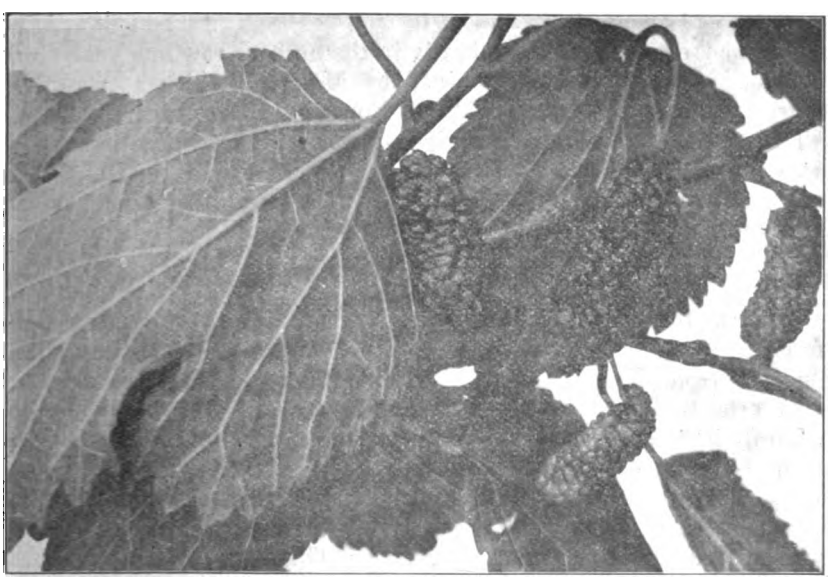
Hicks. Fruit—oblong, straight or curved; medium to large in size—¾ x ½ to 1¼ x ½ inch; color reddish, becoming black; apex rounded, base oblique or rounded; druplets compacted, flattened, medium; styles inconspicuous; sutures narrow and shallow; stem ½ inch long, slender, deeply imbedded in fruit, pubescent; flavor sweetish, insipid; ;quality poor. Season, June to July.

Leaves—Ovate, apex variable, rounded and blunt to long acuminate, often-lobed; leaves on young growth deeply four to six-lobed, with deep and rounded sinuses; base truncate or rounded and cordate; very large—3 x 4 to 6 x 4½ inches; blade thin, rough, thickly pubescent beneath; dull green in color, lighter green beneath; margin strongly serrate, teeth large; veins large and prominent; light yellowish, white beneath; pubescent beneath, especially on the veins.

Tree—Large, vigorous grower; very heavy, continuous bearer. Originated at Macon, Ga. Introduced about 1850 by Simri Rose. Good for swine and poultry; too poor flavor for eating purposes. Obtained from G. L. Taber, Glen St. Mary, Fla., and J. Van Lindley, Pomona, N. C.



STUBBS.

Stubbs. Fruit—Form oblong, curved and slightly irregular; very large—1½ x ½ to 2 x ⅝ inches; color bright, deep red, becoming black; apex rounded, base usually oblique and somewhat irregular; druplets compacted, flattened, medium in size; syles present; sutures shallow and narrow; flavor sub-acid; vinous, sharp; quality good. Season, June to August.

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Leaves—Ovate, somewhat variable, often two to three-lobed, sinuses deep and narrow, apex abrupt; base truncate or oblique; size 4 x 3 inches, thick, smooth above, rough beneath; dark green color; margin irregular, often broken, teeth variable, large, singly or doubly serrate. Veins very prominent, white; pubescent on under side.

Tree—Very large and vigorous; very prolific. Originated near Duplin, Ga. Mr. P. J. Berckmans introduced it about 1887. Specimens from G. L. Taber, Glen St. Mary, Fla.

Townsend. Size medium—1 inch by ½ inch; oblong, slightly curved; black; rounded at both base and apex; druplets long and narrow, 3-16 by 1-16, not permanent; sutures rather shallow; flavor sweetish, not differing from other mulberries. Season early; ripening at Glen St. Mary during the latter part of March and the month of April.

Leaves—Ovate in shape; apex short, with short acuminate point; base cordate, often unequal; size medium to large—4½ x 3 to 5½ x 4 inches; surface even, slightly rough; lower surface rather smooth; color shining dark yellowish green; margin regular, sharply serrate; veins prominent, whitish; pubescence only along the veins; petiole stout, 1 to 1¼ inches long.

Prolific trees fruiting abundantly in the nursery row one year from grafting. Original scions obtained by Mr. G. L. Taber from Mr. Andrew Townsend, Glen St. Mary, Fla., in 1903.

The fact that this mulberry ripens so much ahead of other varieties in North Florida, a characteristic which it will retain, doubtless, in other parts, should give this fruit a prominent place among the varieties of this fruit.

Varieties Derived from *Morus latifolia.*

This was the most important species during the silk industry craze of 1830-'39. It is a native of China, and was introduced into America from France about 1826. It is a vigorous grower, but never attains a very large size. The leaves are very large, rough, and dull in color. The fruit is black and sweet. This species has given rise to one important variety—the Downing—which has practically disappeared from cultivation. It has been supplanted by the New American, which is a much better variety; this latter variety is often sold under the name Downing. This species is used almost entirely in the South as a stock for the other species of mulberries.

The Black Mulberry (*Morus nigra, Linn*). This is the species cultivated in Europe for its fruit. It is almost unknown in this country at the present time. About fifteen years ago the Black Persian, a variety belonging to this species, was cultivated in parts of the South; but at present no nurseryman in the South catalogues it, so far as we know. The P. J. Berckmans Company, of Augusta,

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Ga., writes us as follows, regarding this variety: "We used to cultivate the Black Persian Mulberry years ago, but we have lost it. It makes a very dwarf growth, and is unsatisfactory here."

USES.

The mulberry has not been put to many uses, and has not been as extensively used as its merits indicate. The fruit of the best varieties is very good when eaten fresh. Some of the varieties ripen their fruit over a period of several months, which is not true of any other fruit. It can also be used for pies, and jellies, and those who have used them say that they are quite good.

The tree is a rapid grower and makes a splendid shade tree, especially around stables and stock yards.

No better fruit is known for swine and chickens than the mulberry. Some trees produce as high as ten or twelve bushels of fruit, and during the long fruiting period, pigs and chickens need little other food. They also grow well in hog pastures and chicken yards, and give excellent shade.

They serve an excellent purpose near cherry trees and on strawberry plantations in attracting birds away from these fruits. As long as there are ripe mulberries close at hand, the other fruit will suffer very little from birds.

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THIRTIETH ANNUAL REPORT

OF THE

NORTH CAROLINA

Agricultural Experiment Station

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

FOR THE

Year Ending June 30, 1907,

Including Scientific Papers and Bulletins Nos. 195, 196.

West Raleigh, North Carolina.

RALEIGH:
PRESSES OF EDWARDS & BROUGHTON PRINTING CO.
1908.

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CAMBRIDGE, MASS.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE

S. L. PATTERSON, *ex officio* Chairman, Raleigh.

C. W. MITCHELL.....Aulander.	A. T. MCCALLUM.....Red Springs.
J. J. LAUGHINGHOUSE.....Greenville.	J. P. MCRAE.....Laurinburg.
WILLIAM DUNN.....New Bern.	R. L. DOUGHTON.....Laurel Springs.
ASHLEY HORNE.....Clayton.	W. A. GRAHAM.....Machpelah.
R. W. SCOTT.....Melville.	A. CANNON.....Horse Shoe.

STATION STAFF

GEORGE T. WINSTON, LL.D., President of the College.

B. W. KILGORE.....Director.
W. A. WITHERS.....Chemist.
TAIT BUTLER.....Veterinarian.
F. L. STEVENS.....Biologist.
C. B. WILLIAMS.....Agronomist.
C. M. CONNER.....Agriculturist.
W. N. HUTT.....Horticulturist.
J. S. JEFFREY.....Poultryman.
FRANKLIN SHERMAN, JR.....Entomologist.
WM. KERR.....Assistant in Field Experiments.
J. C. KENDALL.....Assistant in Dairy Husbandry.
W. A. SYME.....Assistant Chemist.
F. C. REIMER.....Assistant Horticulturist.
J. G. HALL.....Assistant in Plant Diseases.
A. F. BOWEN.....Bursar.

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

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LETTER OF TRANSMITTAL.

RALEIGH, N. C., June 30, 1907.

To His Excellency, ROBERT B. GLENN,
Governor of North Carolina.

SIR:—I have the honor to transmit herewith the report of the operations of the Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts, for the year beginning July, 1906, and ending June 30, 1907.

Very respectfully,

S. L. PATTERSON,
Chairman Board of Trustees.

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LETTER OF SUBMITTAL.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,
OFFICE OF THE DIRECTOR,
RALEIGH, N. C., June 30, 1907.

HON. S. L. PATTERSON, *Chairman Board of Trustees.*

SIR:—I have the honor to submit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts, for the year ending June 30, 1907.

Trusting that this report will prove satisfactory, I am,

Very respectfully,

B. W. KILGORE,
Director.

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THIRTIETH ANNUAL REPORT

OF THE DIRECTORS OF THE

N. C. AGRICULTURAL EXPERIMENT STATION

For the Year Ending June 30, 1907.

BY THE DIRECTOR.

This report covers the work of the Station from July 1, 1906, to June 30, 1907.

CHANGES IN STATION STAFF.

H. H. Hume, Horticulturist, severed his connection with the Station on September first and his place was filled by the election of W. N. Hutt. R. H. Harper and O. L. Bagley resigned as assistant chemists and were succeeded by W. A. Syme. The work of C. W. Burkett as Agriculturist has been carried on by C. B. Williams and C. M. Conner. R. S. Woglum, Acting Entomologist, was succeeded by Franklin Sherman, Jr., as Entomologist.

WORK IN THE AGRICULTURAL DIVISION.

The operations in this Division of the Station have been mainly in continuation of the experiments of the previous years in testing cotton, corn, cowpeas, and soja beans with a view of determining the varieties best suited to our conditions, their fertilizer requirements and methods of cultivating and handling the crops and their improvement by careful selection. The work with alfalfa has been enlarged to meet the increased interest in this crop, and a considerable amount of work with grains, especially wheat and oats, has been inaugurated.

WORK IN THE CHEMICAL DIVISION.

In the Chemical Division study has been continued of nitrogenous fertilizer materials and the conditions under which they are converted into food most suitable for crops, together with the bacteria which bring this about. This work is being done in co-operation with the Biological Division.

Some work has been done with the sweet potato to determine its suitability for the production of alcohol and analyses have been made of samples for nitrogen, formaldehyde, nitrates, etc., in connection with other work.

WORK IN THE BIOLOGICAL DIVISION.

The diseases to which plants are subject are either increasing annually, or else we are only finding from year to year ones which have

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long been with us. Investigations have been continued this year in the study of watermelon wilt, in efforts to obtain one or more varieties which would resist this disease and at the same time have good shipping and eating qualities. This work has been in progress for several years, in co-operation with the U. S. Department of Agriculture. Some good melons have been obtained, but they have not been grown sufficiently long to have their qualities fixed.

Granville tobacco wilt studies have been continued in that section. A large number of varieties have been tested, a few of which have shown good qualities of resistance. No method of combatting the disease has yet been found, though the nature of the trouble is known to us.

In the eastern part of the State, particularly in Chowan county, considerable damage is done by a sweet potato wilt. Investigations on this were begun last season. Arrangements have been made for a continuation of this the present year.

Investigations have been conducted on soil bacteriology in co-operation with the Chemical Division, tests being made of a large number of cultures for inoculating leguminous crops and a collection of the fungus diseases of the State begun.

A new disease of chrysanthemums has been found and possibly a method of combatting it.

The most important scientific investigations under way are in connection with apple diseases and lettuce drop. Several new diseases of the apple have been found, among them being disease of the fruit, a fruit rot, a disease of the twigs, a trunk rot, and a canker disease. Studies are being made of these along with troubles already known, among which are the apple leaf spot, the apple rust, and black rot, together with methods of overcoming these troubles.

In connection with the lettuce drop extensive experiments at New Bern have been conducted to test various methods for the treatment of the bed with a view of the extermination of the disease. These experiments have included heat and different chemicals.

The correspondence of this division of the Station has been large, which is good evidence of its usefulness.

WORK IN THE VETERINARY DIVISION.

The work in the Veterinary division is largely provided for by the State Department of Agriculture, a portion of the salary of the Veterinarian only being paid by the Station.

The main efforts of the Veterinarian have been directed toward the extermination of the cattle or fever tick. Methods have been worked out which are being applied on a large scale with most satisfactory results, several counties being freed each year from this pest and relieved from the quarantine restrictions. A great deal of at-

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tention is given to the general live stock interests of the State and to the suppression of contagious diseases.

WORK IN THE POULTRY DIVISION.

The poultry work has proceeded along the usual lines of testing different breeds for comparative egg production, methods of preserving eggs, including the keeping qualities of fertile and infertile eggs, methods of handling and feeding and care of chickens; the use of different incubators and brooders; and special work in pedigreed fowls for egg production. In this latter trap nests have been used and a record of all hens kept. These have shown some of the hens to be specially prolific layers, while others have given no eggs. The eggs from the heavy layers last year and this have been hatched separately and the chickens so marked that the best of them can be selected for a continuation of this work. This is a line of especial interest and value in poultry production.

A comparison has been made of dry and wet mash feeding with results favorable to dry feeding, as indicated by the specially good health of the fowls and the increase of eggs from dry fed fowls. There is a large saving of time in dry feeding.

Tests have also been made of the value of green feed for laying stock.

A Bulletin on Farm Poultry has been prepared giving in addition to matters of general interest to the poultry raiser, the more important results of the experimental work referred to above.

An additional building has been added the past season for keeping male birds and a windmill for supplying water. The barns and poultry houses have been painted.

The correspondence and calls for the Poultryman's services, together with the Institutes which he has attended, show a growing interest in the poultry work; the correspondence the past year amounted to something like a thousand letters.

WORK IN THE ENTOMOLOGICAL DIVISION.

With the exception of a part of the salary of the Entomologist, the entomological work is provided for by the State Department of Agriculture. The most serious insect pest to fruit crops is the San Jose scale. Experiments have been made this season in a number of orchards, especially that of the Candor Fruit Company, in Montgomery County, where over thirty thousand trees were treated, with "Scaleicide" with good results.

Preliminary experiments in the control of plum and peach curculio by spraying with arsenate of lead in water or the Bordeaux mixture have also been made with good results, though it is desirable to continue this work another season before drawing conclusions.

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Arsenate of lead in water has proven itself very effective in the destruction of the tobacco flea beetle on young plants.

Study has been made of cabbage insects, especially the cabbage louse, harlequin cabbage bug, and the white cabbage butterfly.

These investigations will be continued as time permits.

DAIRY WORK.

Under the direction of Prof. C. M. Conner, Mr. Kendall has made experiments on the acid content of milk, the effect of the period of lactation, and of acid food, on the acidity of fresh milk; and a feeding experiment to compare the value of saccharine feed with wheat bran; treatment of milk and cream contaminated with garlic and means of preventing it; a study of the normal composition of North Carolina milk, and the preparation of records of dairy herd of grade and scrub cows with a view of its improvement by selection and breeding.

PUBLICATIONS.

Bulletins have been issued as follows:

No. 195.—Farm Poultry, by J. F. Jeffrey.

No. 196.—Some Apple Diseases, by F. L. Stevens.

The reports of the heads of the several divisions of the Station and financial statement follow:

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REPORT OF THE AGRICULTURAL DIVISION.

PROF. B. W. KILGORE, *Director.*

DEAR SIR:—The following are the main lines of work that are being conducted in this Division:

Alfalfa.—For some time past greatly increased interest has been manifested throughout the State in the growth of alfalfa, and as a result, during this time many inquiries from different localities concerning the value and adaptability of this plant to North Carolina conditions, as well as to the proper method of preparation of soil, time of planting, kind and amount of fertilizer to use, etc., have been received. In response to this popular demand for definite information eighteen experiments designed especially to study the fertilizer requirements of this legume when grown upon our soils have been put out during the past year. In addition to these, five other plats were sown to alfalfa seed from as many different sources and of as many different varieties to ascertain the varieties best suited to our conditions of soil and climate.

Clovers, Cowpeas and Soy Beans.—During the year fifteen plats have been sown to alsike, mammoth, medium red, crimson and white blooming crimson clovers, the plats being so arranged and treated as to study in a comparative way the response in yield of hay of each clover to different fertilizer treatments. Thirty varieties of cowpeas and thirty-four of soy beans are being tested to determine what ones are most prolific of seed and hay.

Wheat and Oats.—Ten leading varieties of wheat and six of oats are being tested on one-twentieth acre plats under the same soil and fertilizer treatment to ascertain their relative yields. As these two cereals are grown to a considerable extent in the State the use of the most prolific varieties is of the most vital importance.

Cotton and Corn.—With these there are thirty-eight one-twentieth acre plats being devoted to fertilizer tests of cotton and thirty-two to corn. The fertilizing constituents on these plats are combined in different proportions so that the most economical fertilization may be determined for these crops. In addition to these, six plats are used for culture tests; fifteen for rotation tests; sixteen for distance tests of cotton and corn; and thirty-four for variety tests of corn.

Breeding Tests of Corn.—Several plats are given over to a study of the effect of selection of corn upon yield. This work was begun three years ago by selecting during the fall seed for the following year's planting from one-eared, two-eared, three-eared and four-eared stalks, and planting each of these selections in different plats. The appropriate selection of seed from the different plats is being continued and the yield of seed corn from each plat is recorded.

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For instance, on the plat planted in corn that was produced on ears that were only one to the stalk, the selection of seed for next year's planting from this plat was from stalks bearing only one ear per stalk; and so on for the two, three and four-eared kinds.

There is no more vital subject for our farmers than that of seed selection made in the proper way.

While the agricultural work has been increased this year, most of the experiments referred to above have been under way for a number of seasons, and will be continued until sufficient data has been collected to justify a publication of the results.

Respectfully submitted,

C. B. WILLIAMS,
Agronomist.

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REPORT OF THE CHEMICAL DIVISION.

PROF. B. W. KILGORE, *Director.*

SIR:—I take pleasure in submitting the following report of the operations of the Chemical Division during this year.

The main work of the Division has been a continuation of the study of nitrification in the soil, and in this work we have been greatly helped by the co-operation of the Bacteriological Division and the appointment of Mr. Temple as special assistant. In addition to the study of nitrification we have made some investigations of the sweet potato, have made determinations of nitrogen in samples sent out by the referee of the Association of Official Agricultural Chemists, and of formaldehyde in some samples of the commercial article for the Bacteriological Division, have made an analysis of soil for the Bacteriological Division, and have determined the amounts of nitrates and nitrites in the garden soils of the neighborhood. Of these it will be necessary to refer to only a few.

Sweet Potato.—Alcohol is produced from the sweet potato by transforming the starch into sugar and by fermenting the sugar. The sweet potato has not been used in the United States for making alcohol, although the percentage of starch in it is greater than in the Irish potato. The sweet potato contains a considerable quantity of cane sugar already made. The climate of the Southern States is peculiarly adapted to the growing of sweet potatoes, and North Carolina leads in their production. It would seem then that the alcohol industry would be very profitable in the South if there were an economical method for the use of the sweet potato for this purpose. Experiments at the South Carolina Station show that as high as eleven thousand pounds of sweet potatoes can be grown per acre under intensive cultivation. In the potatoes grown in these experiments over twenty per cent of starch was found, and in addition to this as high as six per cent of fermentable sugar. There ought to be produced about one gallon of alcohol from a bushel of sweet potatoes, or 200 gallons per acre. The composition of the sweet potato is shown by analysis at the California and Texas Experiment Stations (17 varieties of each) is as follows:

	Cal.	*Texas.*
Water	70	70
Ash	1.08	1.14
Protein	1.86	2.41
Fat	0.95	0.99
Total sugar	5.95	6.81
Nitrogen free extract	23.60	24
Fiber	2.51	2.26

W. E. Stone, of Purdue University, made an investigation of the sugars in the sweet potato and showed that there are no reducing

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sugars present, but he found cane sugar to the extent of one and one-half to two per cent. He studied also the effect of baking and found that during cooking a considerable quantity of starch was changed to the soluble form.

The experiments made in this laboratory confirmed the results of Stone as to the presence of cane sugar in the sweet potato, and seemed to show further that there is no reducing sugar present. This was tested in two ways.

The absence of pentosans and pentoses has been shown in this laboratory. This was not touched upon by Stone.

It appears to us from these experiments that there is no reason why the sweet potato might not be used directly for the production of alcohol rather than by taking the usual step of separating the sugar and the starch and producing alcohol from them, the carbohydrates in the potato being starch and cane sugar.

Nitrification.—At the beginning of the work of the Division on nitrification we found it possible to produce nitrates in soils from nearly every soil tested by us, but during the last year or so we have found that the same fields and gardens failed to produce nitrates, which indicates not only instability in the organism but the lack of wide distribution. After failing to find it in the ordinary field and garden soils of the vicinity, we took some very rich soils and succeeded again in securing the formation of nitrates. In some cases we have found that an attempt to cultivate the organism has resulted in the lack of production of nitrates. After succeeding in locating the organisms, our work is now proceeding in a satisfactory way in co-operation with the Bacteriological Division. Dr. Stevens and Mr. Temple are attempting to cultivate and isolate the different organisms in the soils referred to with the view of ascertaining those which produce nitrates. This Division is performing the analytical work, and Mr. Temple is for the present giving himself entirely to the bacteriological work. Our experiments indicate that we shall have interesting results.

Respectfully,

W. A. WITHERS,
Chemist.

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REPORT OF THE BIOLOGICAL DIVISION.

MR. B. W. KILGORE, *Director.*

DEAR SIR:—I beg leave to submit a report of the Division under my charge for the fiscal year now closing.

This Department as organized embraces the subjects, Vegetable Pathology and Bacteriology in the Experiment Station and the same subjects, with Botany in addition, in the Agricultural College. The addition of J. G. Hall to the staff as assistant in plant pathology has made it possible to do much more work with plant diseases than ever before; and the employment of J. C. Temple as assistant in bacteriology has admitted of work in soil bacteriology. I wish to express my appreciation of the ability, interest and enthusiasm of Messrs. Temple and Hall in their respective fields of work, and to acknowledge their efficient aid in carrying on the work of this year as planned.

This Department is well housed in the laboratories of the Agricultural Building, and well equipped with work benches, herbarium cases, miscroscopes, microtomes, incubators, sterilizers and necessary small utensils. An incubator provided with several compartments, each of different temperature, giving a range from 0° to 35°C, has been installed recently; a complete set of *Fungi Columbiani* and *Saccardo's Sylloge Fungorum,* has been secured, also complete bound sets of *Centralblatt für Bacteriologie, Annales Mycologici, Zeitschrift für Pflanzenkrankheiten.*

An excellent incubator room has been constructed. It is lined throughout with metal and asbestos, insulated by four inches of air space on all sides, and is fitted with shelves and lockers made by the Art Metal Construction Company, of Chautauqua, N. Y.

According to the plan (Fig. 1) three kinds of compartments are here provided: Open shelves *a;* Research closets *b,* size 20 by 50 inches, containing three shelves each and provided with lock; and the individual lockers *c,* 5 by 15½ inches, provided with doors but without locks. This arrangement of incubator room gives more space than many ordinary incubators and at very much less expense. The room is heated by a special stove, "Petite Calorifer á gaz," regulated by a Roux U-shaped metallic regulator, "Grande Model," both procured from Weisnegg, Paris.

With these new facilities this department will be enabled to take up more extensive work in plant diseases and bacteriology during the coming year.

The work of the past year may be summarized as follows:

Publications.—During the year the following bulletins have been issued by this Department: Press Bulletin, No. 14, A Serious Lettuce Disease; Press Bulletin, No. 4, Treatment of Oats, Wheat, Rye

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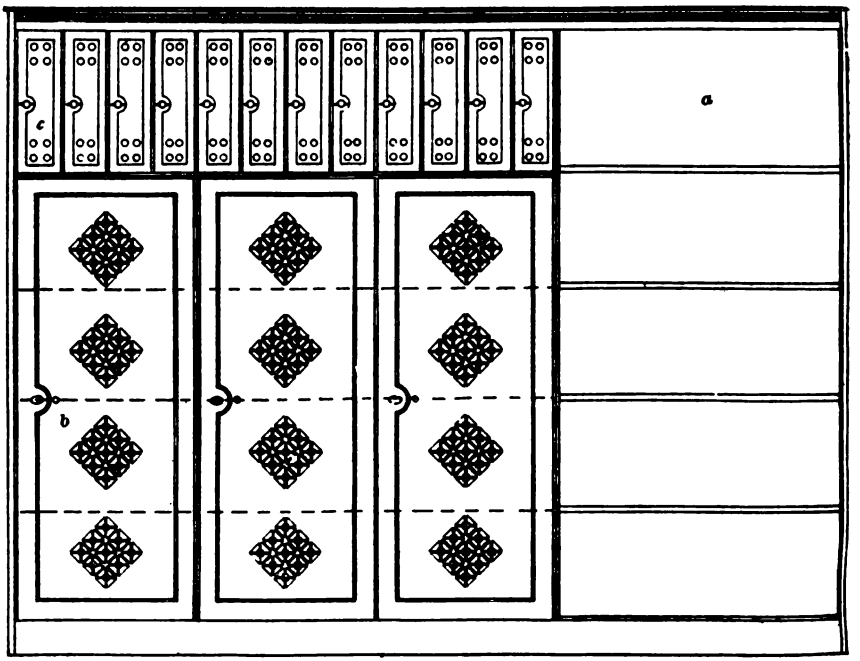

FIG. 1.—Showing arrangement of iron shelving of the incubator.

and Barley for Smut, has been revised and re-issued as No. 15; Bulletin No. 196, Some Apple Diseases, treating of several diseases of the apple tree, hitherto undescribed.

Correspondence.—Many inquiries concerning plant diseases have been received, diagnoses made, treatments recommended, etc. In all 3,743 letters have been mailed from this Department.

A Collection of Fungi for the Experiment Station has been begun, and it is desired to increase this collection as rapidly as possible. The specimens are being properly arranged and systematically cared for, so as to make them of working value.

Plant Disease Survey in Cooperation with the National Department of Agriculture.—Many queries have been sent out over the State concerning the prevalence, and amount of damage caused by various plant diseases. The information thus secured is properly tabulated and preserved for reference.

Lettuce Drop.—This is unquestionably the worst disease affecting the lettuce industry. Extensive laboratory and field study is planned, has been under way for the past year, and will be continued during the coming year.

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Apple Diseases.—The fruit diseases of North Carolina have never been studied systematically, and much remains to be discovered concerning them. The apple diseases have, and will during the coming year, receive particular attention. Two new diseases have already been described and several more are under study in the laboratory to be reported upon later.

Root Tubercle Inoculations.—The widespread interest in soil inoculation, by various means, to secure an abundance of tubercles upon the roots of leguminous crops, and in particular the recent exploitation of the means of inoculation by the use of germs upon cotton lint and germs in liquid culture, have led us to test the efficiency of the most recent form of inoculation, that of liquid cultures. Very numerous accurate tests were made with the bean, cowpea, sweetpea, alfalfa, Canada field pea, vetch and red clover, both upon sterilized and unsterilized soil, inoculated and uninoculated, employing various modes of inoculation. In all some one hundred and ten experiments were made, throwing much light upon the question of inoculation by means of pure cultures. The results of this work will be found on succeeding pages.

Oat Smut.—The dissemination of knowledge concerning the available methods for preventing oat smut has been part of the work of this Department for the past five years. Many reports of efficiency have been received from farmers throughout the State and several laboratory tests have been made. The results of this work will soon be embodied in bulletin form.

Soil Bacteriology.—In co-operation with the Chemical Department, work has been undertaken in the study of soil organisms in their relation to nitrogen. So far the work has been largely of a preliminary character. A report of results will be made later.

Sweet Potato Wilt.—A large number of varieties of sweet potato has been secured through the kindness of the United States Department of Agriculture, and are under cultivation in Perquimans County. The work of last year consisted simply in increasing the stock of each variety on hand. The test of resistance of these varieties will be made this year.

Melon Breeding for Resistance to the Wilt.—Work on melon breeding was continued in co-operation with the National Department of Agriculture. Some thirty-four varieties of resistant melons were tested on sick soil to ascertain their edibility. At planting time and throughout the growing season conditions were adverse to successful melon growing, both in our experimental plots and on adjoining farms. For this reason many of the plots failed completely to produce a crop.

All melons planted possessed considerable resistance, in some cases almost complete resistance to the wilt, but in many strains the citron

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type predominated to a large extent. In other strains many edible melons were produced. In all cases, however, the variation was so great as to interfere with the value of the melon commercially. One variety which has made a good record in previous years, this year produced many edible melons of excellent quality and the vines were of higher resistance to the wilt. The chief objection to this type is its lack of uniformity. Eighteen selections of seed were made for future tests.

Respectfully submitted,

F. L. STEVENS,
Biologist.

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REPORT OF THE VETERINARY DIVISION.

DR. B. W. KILGORE, *Director.*

DEAR SIR:—Pursuant to your request, I have the honor to herewith submit my report as Veterinarian of the North Carolina Station for the year ending June 30, 1907.

The eradication of the cattle fever tick (Boophilus annulatus) continues to be the most important veterinary and animal husbandry question of special interest to North Carolina agriculture and the work of this Division has been continued along the lines followed in previous years, with the view of ascertaining the best methods of accomplishing this object.

For five years this Station, in cooperation with the North Carolina State Department of Agriculture, continued the work of cattle tick eradication, this State being practically alone in the work of applying the facts previously worked out by scientists regarding the habits and life history of the tick, to practical methods of destroying these parasites and our work first demonstrated the feasibility of the complete extermination of the cattle tick over large areas.

The two general methods developed and found most satisfactory have been outlined in previous reports, and briefly stated are as follows:

The first method involves the keeping of all cattle, horses and mules out of the pasture to be cleaned for such a period as will insure the death of all ticks from starvation. If these animals are taken out of a pasture September 1st and not returned until May 1st, it will be free of ticks. Or if they be taken out of the pasture May 1st it will be free of ticks by September 1st.

The winter period, although twice as long, is preferable for the following reasons: The ticks are more numerous and do the cattle more injury during September, October and November; the pastures afford less feed during the long winter period than during the best pasture months, May, June, July and August; and since the cattle carry few ticks May 1st, they are much more easily cleaned before putting on the tick-free pasture. If the cattle owner has only one pasture he may still clear it of ticks by any one of the following plans: He may arrange with a neighbor to pasture his cattle during one period, while he pastures those of his neighbor during the other period, thereby clearing both pastures. Or he may reduce the number of his cattle and divide his pasture by a fence, pasturing one part during one period and the other part the next period. If he does this and the fence be of wire, it will be necessary to move the fence back ten or fifteen feet onto the tick-free portion when the clean cattle are put thereon, for ticks sometimes cross wire fences. Or he may dispose

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of all cattle except a milch cow or two and stake these out or keep them in a small lot and feed them for one or the other of these periods. If none of these plans can be followed, it will pay any man to dispose of all his cattle and be without cattle for one of these periods in order to obtain a tick-free pasture.

If any of the plans suggested by this general starvation method can be followed it will still be necessary to make certain that the cattle are free of ticks when they are put back onto the clean pastures. Cattle may be cleaned of ticks by a thorough application of Beaumont crude oil, repeated in two weeks; or a thorough application of a mixture consisting of three gallons of cottonseed oil, one gallon of kerosene, one quart of tar, and one pound of sulphur, repeated in two weeks, will kill all the ticks; but these applications must be made to all parts of the skin. Or the cattle may be cleaned of ticks if two lots be provided on which no cattle have been for eight months. Keep the cattle in one lot for eighteen or twenty days and then change them to the other lot for the same length of time. By this plan the cattle will almost certainly be cleaned if the weather be warm; but if it be cold, failure may sometimes occur, and it has the further objectionable features that it requires forty days and that feed must be provided during that period.

The second general method of tick eradication is based on the fact that if some substance be applied to the cattle that will kill the ticks on them no mature ticks can drop in the pasture, and if this be kept up for a sufficient length of time the pasture must become tick-free.

Beaumont crude oil is probably the best substance to apply to the cattle, but it is doubtful if even this can be applied as often as necessary for a sufficient length of time to eradicate the ticks in the pasture without slight injury to the cattle. The most favorable times to use this method is to begin September 1st or April 1st and continue as often and as long as necessary to kill all the ticks that get on the cattle.

The objections to this method are that no substance is yet known that, when applied sufficiently often and for a sufficient length of time to insure the destruction of all the ticks in the pasture, is entirely harmless to the cattle; that the cost of materials and labor is too great; and that unless considerable expense is incurred in providing dipping or spraying apparatus the applications will not usually be thorough enough to obtain success. The pastures, however, may be cleaned in this way, and where conditions warrant, its use is advised, but many failures will occur when cattle-owners attempt the use of this method. The work is not usually done with sufficient care and regularity to insure success.

By 1906 it had been demonstrated that the complete eradication of the cattle tick was practicable, and in a measure this work passed

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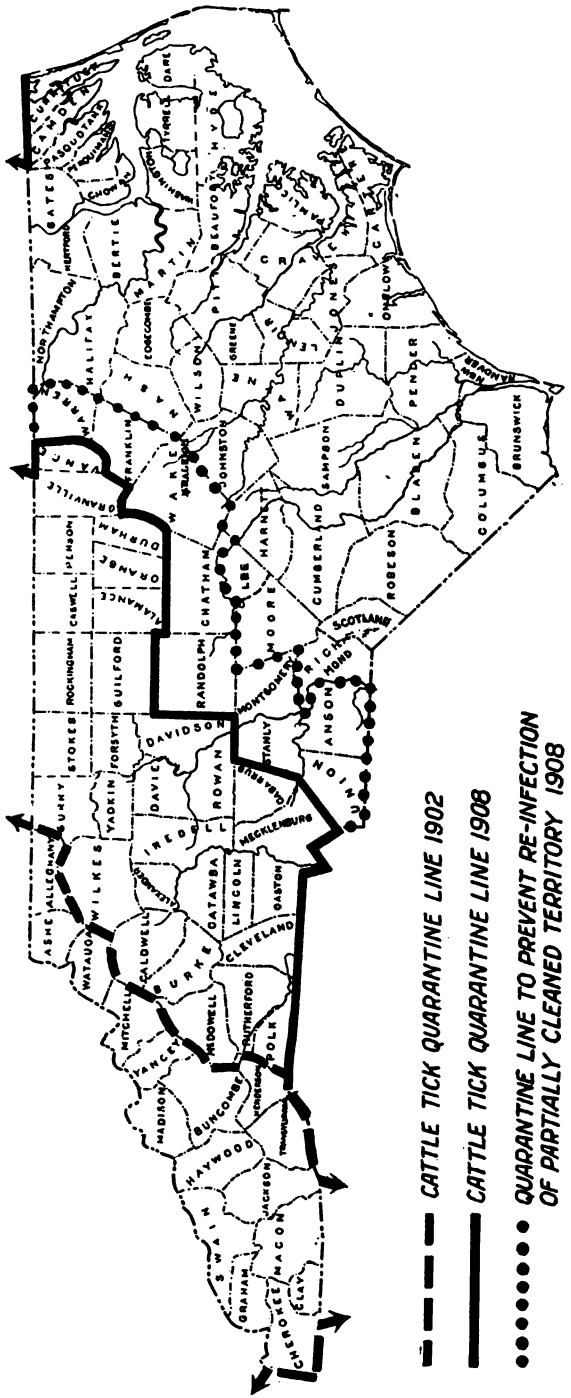
CATTLE TICK QUARANTINE LINE 1902
CATTLE TICK QUARANTINE LINE 1908
QUARANTINE LINE TO PREVENT RE-INFECTION OF PARTIALLY CLEANED TERRITORY 1908

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beyond the experimental stage. Since August, 1906, however, the Federal Bureau of Animal Industry, having obtained an appropriation for cooperating with the several State governments, this work has been carried on in cooperation with that Bureau of the Federal government.

During the season of 1907 cooperative experimental work was conducted in the counties of Union and Anson, in which the spraying with an emulsion of 20 per cent crude Beaumont oil every three weeks while the cattle were still running on the infected pastures was used for the eradication of the ticks. This work was begun rather too late in the season and discontinued too early, on account of lack of funds to accomplish the most good, but the results obtained seem to indicate that while this is a more troublesome and expensive means of tick eradication than the method of taking the cattle out of the pastures and allowing the ticks to die of starvation, it can be made successful and is probably advisable when stock owners can not be induced to adopt the more certain, easier and cheaper plan of vacating the infected pastures.

The practical results obtained to date as affecting North Carolina, over and above demonstrating to the world the feasibility of the general proposition of cattle tick extermination, are as follows: Thirty counties, as shown on the accompanying map, have been freed of ticks and all restrictions on the movement of cattle therefrom been removed. This is certainly already worth to the State, in money saved, not less than $50,000 a year. All of which is respectfully submitted.

Yours very truly,

TAIT BUTLER,
Veterinarian.

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REPORT OF THE POULTRY DIVISION.

PROF. B. W. KILGORE, *Director.*

DEAR SIR:—I beg to submit the following report of the work in the Poultry Division for the year ending June 30, 1907:

The work in pedigree breeding for egg production has been continued during the past year and satisfactory progress has been made. The feeding of dry feeds from hoppers was started the first of the year, and while we have not had a long enough experience with it to say positively that it is better than the wet mash, as far as we have gone with it we are well satisfied with the results. Most of the hens selected from last year's stock for breeders this year have given better egg yields than they did in their first year, and we have hatched a larger percentage of the eggs set this year than ever before, and whether we are right or not we give the change in the manner of feeding the credit for most of the improvement.

A test was made with two lots of barred plymouth rocks of the value of green feed and the results indicate that green feed of some kind is a very valuable addition to the ration, especially where corn is largely used.

A Bulletin on Farm Poultry has been prepared and is now in the printer's hands, and in addition to general poultry information, the results of the experiments carried on during the year are published.

During July and August a number of institutes were attended and talks given on poultry work. In many cases talks were given both at the Men's and Women's Institutes. The interest in most of the counties visited seems to be on the increase, due no doubt to increased price of poultry products and to the campaign that has been started both at the Institutes and in the Farm press in favor of more diversified farming.

The work planned for the coming year includes a study of the principles of heredity, both as to external characteristics and as to prolificacy. The suitability of cottonseed meal for poultry will also be tested both for laying stock and for fattening market stock to determine if it may be profitably and safely fed and in what quantity.

Respectfully submitted,

J. S. JEFFREY,
Poultryman.

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REPORT OF THE ENTOMOLOGICAL DIVISION.

MR. B. W. KILGORE, *Director.*

DEAR SIR:—I submit the following brief report on the operations of the Entomological Division of the Station for the past year:

As has been pointed out in previous reports, the work of this office has been supported mainly by the State Department of Agriculture and the activities of the office are mainly evidenced by the reports and other publications issued from that Department. However, all questions regarding insects which are addressed to the Station are carefully answered, and each year we are able to do a little original work, either in experimentation or in observation, which is properly Station work.

Your Entomologist was not in the State during the nine months from August, 1905, to June, 1906, but during that time Mr. R. S. Woglum, Acting Entomologist, conducted some careful tests against the San Jose Scale at Raleigh and at Southern Pines, which demonstrated that the substance known as "Scalecide" is quite effective when used of the strength of 1 gallon to 12 gallons of water. As this material is readily mixed with water and is then at once ready for use, it promises to become quite widely used, especially by those who for one reason or another do not wish to attempt the use of the Lime-Sulphur Wash. The past season it was used in several orchards in this State, noticeably those of the Candor Fruit Company at Candor, Montgomery County, where about 33,000 peach trees were treated with every evidence of satisfactory results. Preliminary experiments in the control of the peach and plum Curculio by spraying with Arsenate of Lead in water or in Bordeaux mixture have also been made by Mr. Woglum at Southern Pines with very encouraging results, though it would be very desirable to continue work along this line at some future season. The very severe late freeze of the present season compelled us to abandon that work for this year.

During the month of May Mr. Woglum made several interesting observations upon the Tobacco Flea Beetle in Granville County and proved by experiment that the young plants in the seed bed can be protected from this destructive pest by spraying with Arsenate of Lead and water. The same material may be used for dipping the plants just before they are set out. Both these matters were proven in Mr. Woglum's experiments, but as the time was limited, the tests were not as extended as we should like. The results were very encouraging, nevertheless.

During the past month Mr. Woglum has been working upon some problems concerning cabbage insects, and has made notes on the life history and habits of Cabbage Louse, Harlequin Cabbage Bug and

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the White Cabbage Butterfly. Although in none of these cases could the work be carried to the final conclusion, his notes will be carefully written up and placed on file in this office.

Very truly yours, FRANKLIN SHERMAN, JR.,
Entomologist.

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NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATIONS, 1906-1907

DR.

To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ending June 30, 1907, under Acts of Congress, approved March 2, 1887, and March 16, 1906:

Hatch Fund	$15,000.00
Adams Fund	7,000.00

CR.

	Hatch Fund.	*Adams Fund.*
By salaries	$7,708.65	$4,433.33
Labor	1,650.86	522.98
Publications	1,047.44	.....
Postage and stationery	449.09	57.81
Freight and express	59.47	88.25
Heat, light, water and power	136.86	48.88
Chemical supplies	.....	97.59
Seeds, plants and sundry supplies	592.10	163.09
Fertilizers	224.88	125.94
Feeding stuffs	362.34	72.21
Library	9.50	303.62
Tools, implements and machinery	481.76	190.50
Furniture and fixtures	619.36	.....
Scientific apparatus	.....	747.26
Live stock	655.00	.....
Traveling expenses	290.34	148.54
Contingent expenses	15.00	.....
Buildings and land	697.35	.....
Total	$15,000.00	$7,000.00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1907; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $22,000, and the corresponding disbursements $22,000; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress, approved March 2, 1887, and March 16, 1906.

(Signed)

N. B. BROUGHTON,
C. W. GOLD,
B. W. KILGORE,
Auditors.

(Seal.)

Attest: A. F. BOWEN, *Custodian.*

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SCIENTIFIC PAPERS.

THE SPRAYING OF IRISH POTATOES.

By F. L. STEVENS

Experiments have been conducted during the year upon the plantation of D. M. Stanton, of LaGrange, N. C., for the purpose of determining: 1st, whether spraying potatoes for fungous diseases will pay in the eastern section of North Carolina as it does in many other portions of the United States; 2d, to determine which is the better spraying mixture for potatoes in this locality, the ordinary lime Bordeaux or the soda Bordeaux.

The field selected for experiment lay about one and one-half miles southeast of LaGrange, in a region of sandy loam. It was planted to Boone potatoes.

The region devoted to the experiment was selected on account of uniformity of character of soil and lay of the land.

Two rows were left untreated between each experimental plat to obviate any errors which might arise from the spray of one treatment lapping over onto the rows receiving a different treatment. To guard so far as possible against the unfavorable influence arising from the close proximity of diseased plants, the experiment was made on blocks of three rows.

It was the original intention to leave three rows without Paris Green, but it became evident from the inroads of the bugs that such a course would mean the total loss of the crop on these rows, and since the experiment was a co-operative one with Mr. Stanton, such a plan was abandoned.

The following sprayings were made:

1st. May 5.

After the first spraying much mixture was washed off by rain.

2d. May 11.

3d. May 22.

4th. June 1.

The fourth spraying was followed by rain which washed off much of the mixture.

5th. June 20.

The season was throughout unfavorable to potatoes, and Mr. Stanton wrote on May 22, "Tops are making slow growth and I see no prospect of over one-half crop even if good rains should come in the next few days and continue until the end of the season." On May 25 he wrote, "The potato crop is ruined by the drought. * * * We can

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not get a fair test of spraying this year." On June 6 he wrote, "The vines of the rows sprayed are much greener and better looking than on the unsprayed rows." On June 11 he also wrote, "The vines are looking greener and better than those not sprayed." On June 20, my assistant, J. C. Temple, applied the fifth spraying and wrote, "The leaves were greener and were but little affected with the blight, which is getting bad on the unsprayed rows."

Upon digging, on June 30, the following yields were harvested:

	Gross.	Prime.	Second.	Culls.
Soda Bordeaux	335 lbs.	Not recorded.	Not determined.	
Lime Bordeaux	416.5 lbs.	126 lbs.	152.5 lbs.	138
Paris Green and no Bordeaux	353.5 lbs.	100.5 lbs.	117	136

or a gross gain in the yield by the use of the lime Bordeaux mixture of 17.84 per cent in marketable potatoes, a gain of 25.37 per cent of first grade, 30.34 per cent seconds, and 1.44 per cent thirds.

No. 1 sold on an average at $2.25; No. 2 at $1.80; and No. 3 at $0.80 f. o. b., making a cash gain of $26.05 per acre, based on a yield of 75 barrels per acre on unsprayed fields, or a gain of 22.5 per cent.

The cost of the five sprayings, which resulted in this gain, was about $5.00 per acre, making a net gain from spraying with the Bordeaux mixture, under the condition of this experiment, $21.05 per acre.

Mr. Stanton, under date of September 8, writes, "The test was not a good one, yet it shows that lime Bordeaux pays."

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A BACTERIAL DISEASE OF LETTUCE.

By F. L. STEVENS

Specimens of lettuce badly affected with some disease were collected by J. G. Hall at New Bern and sent into the laboratory on April 4, 1907. The disease showed itself upon the plant, in mild infection, as spots upon the leaf. In early age these spots are less than 1 mm. in diameter and are of a pale, yellowish-green color rather than the normal green of the lettuce leaf. Later they turn slightly straw colored and then brown. When the spots attain the brown condition the tissue is seen to be shrunken in thickness, and upon holding such a leaf to the light the diseased spot seems to be surround by, a border 1 or 2 mm. in diameter, of pale green tissue. The infected spot enlarges and as it does so the chief characteristic of the disease becomes apparent, that is, a shrinking and drying of the diseased tissue, resulting in a membranaceous region, in which the veins appear as a striking net work of dark anastomosing threads. (Fig. 2.)

As the diseased areas upon the leaf enlarge many of them become confluent and large regions of the leaf, one-fourth, one-third or one-half, may blend into one continuous diseased spot, throughout which the character as expressed above appears. That is, upon being held to the light, the diseased region appears transparent, with the thickness of tissue paper, and is set with blackened veins. Viewed by reflected light, as when held in the hand or against some dark object, the thinness of the spot and the conspicuousness of the veins are of course not apparent, and the whole diseased spot appears as a dead, blackened portion of the leaf, somewhat resembling a frosted leaf. The disease sometimes involves all of the leaves of the head.

Upon miscroscopic examination no fungous threads whatever were seen, and every diseased spot, young or old, no matter how small, even a piece of tissue 1 mm. square, upon being torn apart in a drop of water, was seen to give forth myriads of bacteria. These issued in every direction from the affected tissue in such clouds as to be distinctly visible to the naked eye to a distance of 1 to 2 mm. These bacteria were rather long rod forms, which stained easily with Gentian Violet. Bits of healthy tissue teased apart and examined in similar fashion revealed the presence of no bacteria whatever.

Bits of diseased tissue were taken with aseptic precautions, teased and diluted, then plated in nutrient beef agar and in cowpea agar, resulting in each case in a practically pure culture of one species of organism. On standard beef agar the colonies when four days old, at 12° to 17° C., attained a diameter of about 0.7 mm. They were circular, smooth, with convex surface. Under the microscope they

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were highly refractive, finely granular, often with a small granular core; by transmitted light they were translucent; the color was that of olive oil. In consistency they were soft.

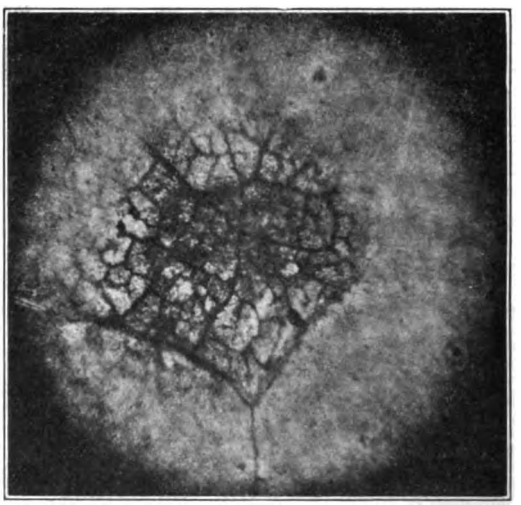

FIG. 2.—A portion of a single spot of the lettuce bacterial disease enlarged, seen by transmitted light showing the extremely transparent nature of the leaves, the veins standing out clearly.

Deep colonies were lenticular to circular, 0.1 mm. in diameter, surface very slightly rough, finely granular, soft.

The streak on beef agar when four days old at room temperature was filiform, convex, smooth, olive-oil colored, translucent, soft.

In broth cultures the fluid was very slightly clouded in three days. There was no membrane, but there was a very fine growth at the surface and a very fine sediment constantly falling. Upon agitation a very fine granular sediment rose from the bottom of the tube.

Several attempts were made to secure inoculations by spraying a liquid culture upon lettuce plants, but the attempts were unsuccessful.

Notwithstanding the failure of securing successful inoculation, the absence of any other causal agent from the diseased spots, the universal appearance of bacteria in practically pure culture, and the general appearance, make it very probable that this disease is caused by bacteria. Indeed it is probably the same disease that was studied by Percival C. Brooks.[1]

This disease was of only slight importance this year, only a few plants being affected. The disease is, however, a serious one to the individual lettuce plant, since an affected plant is entirely devoid of commercial value. If conditions should be such as to admit of the disease gaining a greater foothold in the lettuce beds, it would become of much significance.

[1] Mass. Agr. Exp. Station, 19th Annual Report, January, 1907, p. 163.

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SCLEROTIA ON CARROTS.

By F. L. STEVENS

Specimens of carrots bearing many small, soft spots were found among carrots exhibited at the Horticultural fair at New Bern, May 22. The spot in each case consisted in its younger condition of a sunken area, somewhat soft, and usually bearing in its center a few strands of white, cotton-like mycelium. Frequently ten or twelve of these spots, from an eighth to a fourth of an inch in diameter, were found on a single root, as shown in Fig. 3. In the older stages of the disease these spots enlarged and the whole rotten area was covered with a dense felt of white mycelium.

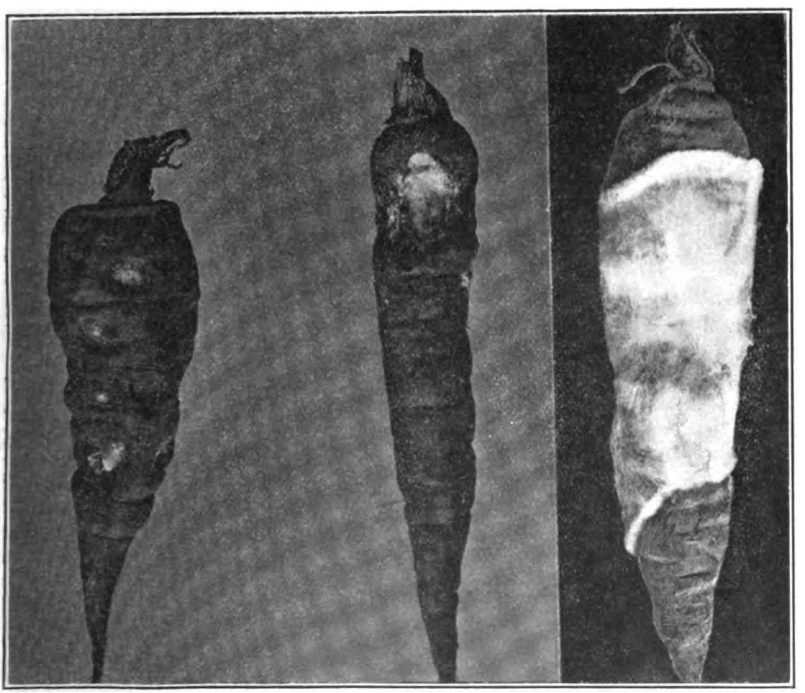

FIG. 3.—Carrots in various stages of decay from the Florida sclerotial disease.

Carrots in an incipient stage of the disease were placed in a moist chamber, and within twenty-four hours there was an exceedingly luxuriant growth of white mycelium extending for an inch or more from the point of original infection. The condition at this time is illustrated in Fig. 3 at the right. A day or two later this mycelium

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extended so as to envelope the whole root, and grow out over the glass of the dish and into the air. At this time there were many minute centers of denser aggregation of the mycelium These regions rapidly assume a spherical form and a yellowish tint, at the same time exuding drops of water. At a little later period these bodies, sclerotia, become a light brownish color and later almost black. In the yellow stage they closely resemble mustard seeds, both in size and color.

The fungus causing the rot is clearly the same as that collected in Florida on egg plant, tomato and several other plants by Prof. Rolfs, and described later with illustrations by Byron D. Halsted, in report of New Jersey Agricultural Experiment Station, 1903.

The distribution of this fungus, as shown by the U. S. Plant Disease Survey Records, kindly furnished me by Dr. W. A. Orton, of the Bureau of Plant Industry, is as follows:

"On Solanum tuberosum, Lycopersicum esculentum, Phaseolus sp., Cucurbita sp., Daphne odorata, at Lake City, Florida, collected by P. H. Rolfs. On tomato at Boston, Georgia; on cowpea at Auburn, Alabama; and on potato at Hastings, Florida."

In northern climates this fungus is unknown as a parasite, although it grows in the laboratory luxuriantly as a saprophyte. No record has been made of it heretofore so far north as North Carolina, and even in the present instance it may be that the fungus made its attack after the carrots were pulled and that it is here rather saprophytic than parasitic.

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THE CHRYSANTHEMUM RAY BLIGHT.

By F. L. STEVENS

The common name chosen for the disease at present under discussion is taken from the most conspicuous symptom of the malady, a blighting of the corolla of the ray flower, resulting in poorly developed, discolored, one-sided heads. (Fig. 4.)

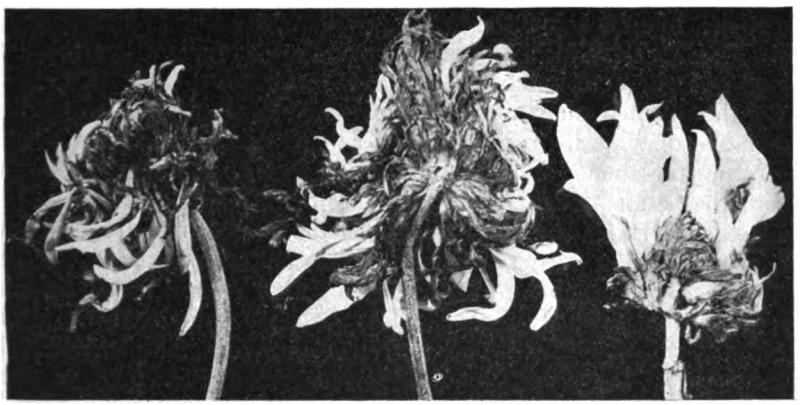

FIG. 4.—Three heads, showing disease as it naturally occurs.

Attention was first called to the disease by a letter from Fayetteville, N. C., dated November 13, 1906, and accompanied by specimens. The disease has been known at that place and has continuously recurred for a period of three years, each year with increasing destructiveness. It was first attributed by the owner of the plants to want of ventilation, but upon its occurrence the second year, the possibility of such a cause was precluded by the conditions. The disease was found upon plants in the open as well as upon those of the greenhouse. The first year it was known it was found only upon late varieties, but during the present year it appeared upon all varieties in the owner's collection, the variety, "Nellie Pockett," being particularly susceptible. The "Golden Wedding," a late yellow variety, always suffers badly in the collection in question. Since receiving specimens from Fayetteville the disease has been found in Raleigh, and it may be of wide occurrence.

SYMPTOMS.—The disease is most conspicuous in the flower clusters which it attacks usually upon one side, either in the bud or during various stages of blooming. The affected blossoms turn straw color or brownish, cease to develop and wither, the discoloration proceeding from base toward tip, on each individual flower, thus distin-

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guishing the disease at once from many disorders which may resemble it superficially. If the case be severe, and the attack be upon a bud while still young, no rays will develop; the head will not open. If the attack be later, a portion of the head, one-half or two-thirds, or more or less, may develop normally and thus by contrast heighten the conspicuousness of the disease. Heads nearly open and apparently healthy may on the following day show one side far progressed in disease. The owner says "it developed so fast that a large, perfect bloom in the morning would be wilted by night."

The receptacle turns black, and the peduncle, to a distance of one to two centimeters below the head may likewise be blackened throughout. Later, shriveling and softening of the peduncle allow the head to nod in a characteristic manner.

On the affected plants, portions of the stem are often blackened to a distance of several centimeters, in a band more or less completely encircling the stem. Frequently this diseased spot is associated with a leaf, the petiole of which also partakes of the discoloration.

Microscopic Examination.—Under the microscope, diseased flowers, rays, corollas, receptacles, peduncles, and the diseased portions of the stem all reveal the presence of a rather coarse, much branchd mycelium, that is easily recognized by its septa, which are numerous and stand out with an especially striking clearness. (Fig. 5.) In the humid region between the flowers, in the head, the mycelium becomes aerial, forming a loose floccose weft, visible to the naked eye. In the hollow pith cavity of the blighted receptacle a similar profuse mycelial development occurs; while on old specimens, in culture dishes pycnidia were also found identical with those which developed in pure cultures, to be described later. Only one fungus was seen and no bacteria whatever were visible.

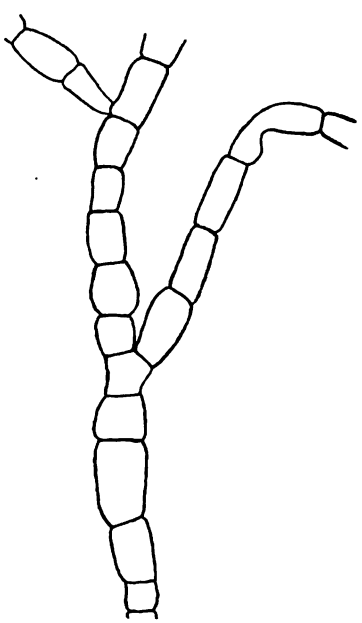

Fig. 5.—Normal Hyphæ, mature, showing septation with slight construction; also the mode of branching.

Isolation.—Diseased ray flowers were removed with sterile forceps and thrown upon solidified pea agar in Petri dishes, several to each dish. Similarly, with aseptic precautions, bits of the wood and bark from diseased peduncles, stems, and from the inside of the receptacle were plated. Each of those cultures, twenty-five or more in number, plated on November 18, resulted within twenty-four hours

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in pure colonies, all alike, of a fungus with a mycelium identical in appearance with that seen in diseased tissue.

THE FUNGUS.—The colonies grew with remarkable rapidity and remained sterile until five days old. Pycnidia were then found in the oldest portions of a colony upon one of the plates. They were amber color as seen with the two-thirds objective and transmitted light, approaching No. 30 of *Saccardo's Chromotaxia* or the YYO[4] of the *Prang Standard Color Scale.* They were coarsely reticulated on the surface, owing to their composition of woven, coarse, mycelial threads. (Fig. 6.) In diameter they ranged from 102 to 204 Mu. (the most usual size being about 150 Mu.) They were round in outline and elevated from the surface, hemispherical. Grown upon corn and also upon the apple agar, the pycnidia were very much darker, almost black. The ostiolum seemed entirely absent in many pycnidia which developed deep in the culture medium, but was

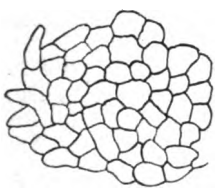

FIG. 6.—Surface view of pycnidum showing reticulation.

FIG. 7.—Spores from pycnidia grown on cow pea agar

present in all growing upon the surface of artificial media or upon natural substrata. The spores were regular and oblong or quite irregular oblong or swollen and rounded at one end and pointed at the other end. Regular-oblong, however, is the prevailing type, with a pronounced tendency toward irregularity. (Fig. 7.) One septum, more easily seen in stained preparations, is visible in most of the older spores; though young or small spores and many larger and older ones do not show septation. The septum is frequently central, but there is a tendency for it to be located nearer to one end than to the other. Rarely two septa or even three are present in one spore. The spores measure from 3 to 6.2 Mu. in thickness by 10 to 20 Mu. in length; 6.2 Mu. by 18 Mu. being the usual size. The spores are hyaline or of very slightly greenish tint. In mass, as extruded from ripe pycnidia they appear slightly pink. The walls of the spores are evidently mucilaginous since the spores, as they are pushed from the pycnidia upon the absorbtion of water, issue in worm-like coils, in which coils they adhere for considerable time, though they are not in visible contact. The spores germinated rapidly in water (Fig. 8), practically every spore germinating. In germinating the septum appeared in all spores, and 1 to 3 germ tubes protruded from each cell. These tubes rapidly became richly septate, and the protoplasm highly vacuolate.

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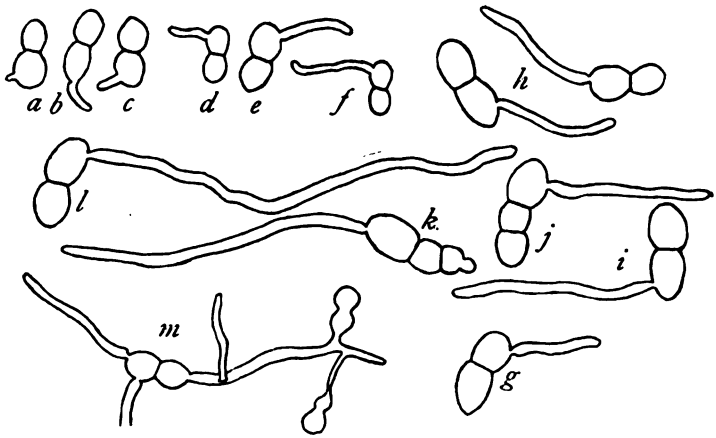

FIG. 8.—Stages in the germination of spores; e and f—c and d respectively, drawn one hour later; c and d drawn at 6 hours of age, and e and f at 7 hours; m 15 hours old.

Studied in microtome section it is seen that the spores are borne from all inner portions of the pycnidial wall (Fig. 9) except the very short neck of the ostiolum, each spore originating singly on the end of a very short (about 2 to 5 Mu.) stalk (Fig. 10). These sporophores are lateral branches of the mycelial threads which constitute the pycnidial wall. The pycnidium originates within the host tissue, *i. e.*, immersed, but rapidly enlarges to burst the overlying epidermis, so that the mature or even half grown pycnidium appears superficial. There is no especial aggregation of mycelium below the base of the pycnidium.

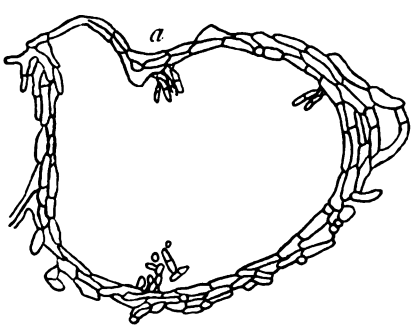

FIG. 9.—Section of pycnidium. a, neck of ostiolum.
FIG. 10.—Portion of pycnidial wall in section showing method of spore attachment.

The pycnidium in very young stages is solid, without cavity. Later a spore cavity develops, though apparently no more rapidly than is necessitated by spore production. In the youngest pycnidia having a spore cavity, the surrounding wall is composed of several (five to eight) layers of mycelium. As the spore cavity becomes distended the wall becomes thinner until at maturity it is composed of only one, two or three layers of mycelium, while the region of the ostiolum becomes one layer thick and eventually ruptures.

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This fungus clearly belongs to the section *Hyalodidymæ Sacc.* of the *Sphærioideæ* Sacc. and seems closest in affinity to the members of the genus *Ascochyta.* The possession of a slight beak, which, however, is always very small and often entirely absent, might throw it into the genus *Rhyncophoma* Karst, but members of that genus are typically upon wood, usually saprophytic and have a more pronounced beak.

Since no *Ascochyta* or indeed any other species of the *Sphærioideæ Hyalodidymæ,* which could by any possibility be identified with the species considered in this paper, has come to my notice as growing upon the Chrysanthemum or any of its kin, I regard this as a new species, for which I gave the following description:*

ASCOCHYTA CHRYSANTHEMI STEVENS.

Pycnidia; few, immersed, early erumpent, single or scattered, round, hemispherical, amber colored, 100-200 Mu., mostly about 150 Mu.; ostiolum central, small, dark bordered, often raised by a short neck; surface reticulate; pycnidia, on agar media irregular, often with two ostioles and varying much in size, black in color. Mycelium abundant, innate also superficial, aerial, floccose, richly septate.

Spores oblong, straight or irregular, 3 to 6.2 Mu. by 10 to 20 Mu., mostly 6.2 by 10. Ends obtuse or acute; septum usually one, often obscure, rarely 2 or 3, usually without constriction until germination; protoplasm vacuolate, hyaline or light pink in mass.

Habitat; in corollas, heads, petioles and stems of cultivated plants of Chrysanthemum Indicum, causing blight. North Carolina.

CULTURE CHARACTERISTICS OF THE FUNGUS.

THERMAL RELATION.—Cultures in Petri dishes on cowpea agar were inoculated December 8, '06, and placed in darkness at three temperatures with the results appearing in the adjoining table.

TABLE I.—INOCULATED DECEMBER 8, GROWTH IN MM.

Plate Number	Place	Days of Month—December											Daily Average
		9	10	11	12	13	14	15	16	17	18	19	
	Temp. min.	--	--	12	12	18	17	18	--	12	--	11	16
	Temp. max.	--	--	20	20	21	21	20	--	18	--	17	19
1	Room	2	4	--	12	15	18	22	25	26	33	39	3.5
2	Room	2	3	--	12	15	18	22	25	26	33	39	
	Temp. 30 to 35.												
35	Incubator	3	3	--	Con	tam	i	nat	ed.	--	--	--	2.2
36	Incubator	3	3	--	?	?	--	8	11	15	22	25	
	Temp. min.	3	10	1	3	1	6	9	10	--	14	--	6.3
	Temp. max.	17	18	14	7	16	21	22	21	22	14	--	17.2
37	Outdoors	0	2	--	?	--	--	7	11	14	19	22	2.
38	Outdoors	0	2	--	--	--	--	7	11	14	19	22	

*Botanical Gazette, Vol. 44, October, 1907, p. 241.

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The growth both outdoors in the cold, and in the incubator, was exceedingly irregular, stunted or slow, while that of room temperature was very much more rapid.

In addition to being an unfavorable temperature for growth, the heat of the incubator produced great irregularity in the zonal development; threads started vigorously, stopped suddenly, and growth began in another direction, so that all regularity of zone formation was lost. Much of the mycelium also became encased in a dark coat, as described under the effect of cowpea leaf agar below. The plates kept at outdoor temperature, while they maintained a fair regularity in the formation of zones, did not make the same number of zones as the cultures kept at room temperature. The number of zones made in the room temperature being six, while that outdoors was four.

Acid Relation.—Cultures in lettuce agar in dark at room temperature in various degrees of acidity gave the following record:

Table II.—Inoculated December 13, Growth in mm.

Plate	Drops of Normal Acid or Alkali Per Tube	Fuller's Scale	Inoculated.	Day of Month—December						Average Per Day
				14	15	16	17	18	19	
25	10	+40	12-13	?	0	0	--	--	--	----
27	5	+20	12-13	?	0	0	--	--	--	----
49	0	0	12-13	2	3	7	12	15	18	3.1
31	5	—19	12-13	gr.	3	5	11	14	16	2.6
29	10	—39	12-13	?	2	3	8	9	10	1.6
34	15	—59	12-13	?	0	0	2	3	4	.7
33	20	—99	12-13	?	0	0	gr.	5	6	1.

It is clearly seen from these data that a neutral medium, or one only slightly alkali, favors best the growth of this fungus.

In the plates bearing 10, 15 and 20 drops of normal alkali there was no formation of zones at all. In the plate bearing five drops of alkali two zones were formed.

The effect or lack of effect of light upon rapidity of growth is exhibited in the following table; cultures grown at room temperature on cowpea agar:

Culture Kept in Light and in Darkness, Inoculated December 8, Growth in mm.

Plate		Inoculated	Day of Month—December										Average Per Day
			9	10	11	12	13	14	15	16	17	18	
1	Light ...	12-8	2	3	5	12	15	18	25	26	33	39	3.9
2			2	3	5	12	15	18	25	26	33	39	3.9
3	Dark	12-8	2	3	5	13	14	18	22	25	31	37	3.7
4			2	3	5	12	14	18	22	25	31	36	3.6

The cultures in light and dark agreed almost absolutely in rapidity of growth, a slight difference of one or two mm. noted at the end of ten days growth, being so small as to be insignificant.

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GROWTH IN VARIOUS MEDIA.—Cultures in agar with various nutrients at room temperature in the dark grew as follows:

INOCULATED DECEMBER 13, 1906, GROWTH IN MM.

Plate	Medium	Inoculated.	Day of Month—December.							Jan. 12
			14	15	16	17	18	20	21	
	Temp. min.		17	18	--	12	--	--	--	
	Temp. max.		21	20	--	18	--	--	--	
9	Pure agar	12–13	Grew	4	6	11	----	----	----	65
10				4	7	11	14	----	----	70
7	Pea agar	12–13	Grew	4	6	10	13	----	----	18
8				4	6	10	14	----	----	18
15	1% Peptone agar	12–13	Grew	3	5	9	9	----	----	70
16				4	7	10	11	----	----	70
11	1% Glucose agar	12–13	Grew	5	9	15	1	----	----	80
12				5	8	13	17	----	----	80
13	5% Glucose agar	12–13	Grew	6	11	16	21	----	----	70
14				6	11	16	21	----	----	75
17	1 % Starch agar	12–13	Grew	4	6	10	11	----	----	------
18				4	7	11	12	----	----	------
	Date	12–8	9	10	11	12	13	14	15	Jan. 12
	Temp. min.				12	12	18	17	18	
	Temp. max.				20	20	21	21	20	
5	Standard beef agar	12–8	1.5	2	5	9	10	11	15	52
6	Cowpea agar		1.5	2	5	10	12	13	17	
3	Standard beef agar	12–8	2	3	5	12	14	18	25	32
4			2	3	5	12	14	18	25	
39	Standard beef gelatine	12–8	2	2	4	6	8	11	17	35
40			2	2	4	6	10	12	17	

Colonies grown in *pure agar* and those upon pea agar were of the same general appearance, thin, colorless, and structureless; zone formation being entirely absent. A very few pycnidia were produced. By increasing the richness of the pea agar to 4 per cent pycnidia were secured, but without change in other characters. The growth in pea agar was no more rapid than that on pure agar, but was much more dense; the mycelium was colorless and very few pycnidia developed.

One per cent *peptone* adds nothing to the nutrient value of the medium for this fungus. Growth comes to an end earlier than in pure agar or other media and there are no pycnidia, no color to the mycelium, and only a very slight indication of zonation.

Glucose.—Two and 5 per cent favor growth, the 5 per cent being slightly better than the 2 per cent. No pycnidia developed, but there

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is marked though irregular zonation, and the whole mycelium develops a striking, intense blackness. The septation and cell contents are normal and the color rests with the cell wall.

Starch.—One per cent did not increase the rate of growth, although upon microscopic examination it was clear that the starch grains were digested almost as soon as the advancing threads of the fungus reached them, and growth continued long in these plates. The effect of starch upon the general appearance of the colony and upon the mycelium was precisely as in the glucose plates.

In *Standard beef agar* and *gelatine* growth was about as with peptone agar, though it continued for a longer time. The mycelium was

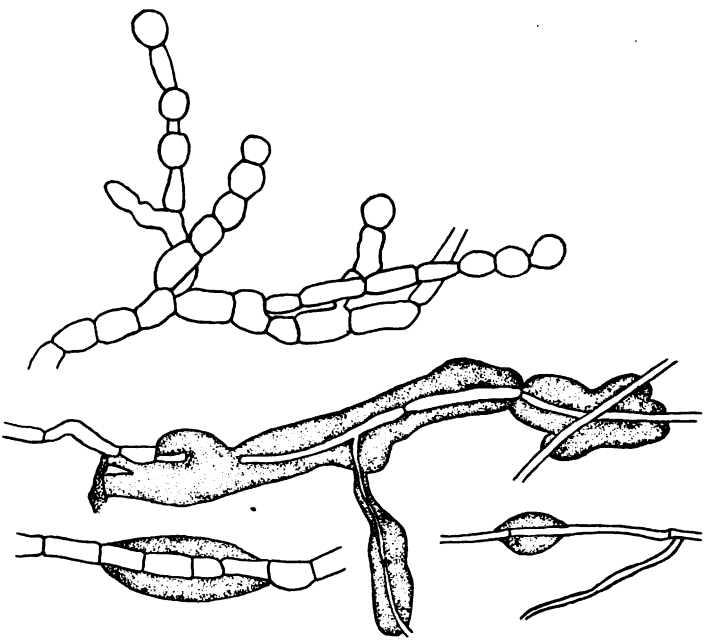

FIG. 11.—Abnormal hyphæ, mature, as grown in gelatine, the cells being unusually swollen.
FIG. 12.—Thickening of hyphæ, produced by too high temperature or an excess of nitrogenous food.

of abnormal, irregular character (Fig. 11) and there were no pycnidia nor any development of color nor of well marked zones.

On *beef gelatine* the growth was more uniform than on beef agar, and the zones were somewhat clearly marked, liquifaction following in the wake of the mycelium, lagging about four or five mm. behind the mycelial tips.

In *litmus-lactose agar* the colonies developed as on beef agar without acidity.

Upon *cowpea leaf agar* the growth while exactly parallel in rapidity with the growth upon the cowpea agar, exhibited remarkable differences in the structure of the colony, the number of zones being much

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less and consequently of much greater breadth. The mycelium also clung closer to the medium, was less floccose and less aerial, and in the older region of the mycelium the cells became extraordinarily thick and short and assumed a dark color. In some instances the protoplasm within the cell rounded off and became invested by a thick brown coat. In other instances a similar brown coat of much greater thickness, often four or five times as thick as the diameter of the mycelium, would form around the mycelial threads. (Figs. 12 and 13.)

Cowpea agar proved the best medium for the growth of the fungus, the concentric zones forming with great regularity, five dense zones and six lesser zones being formed in a period of eleven days. In the

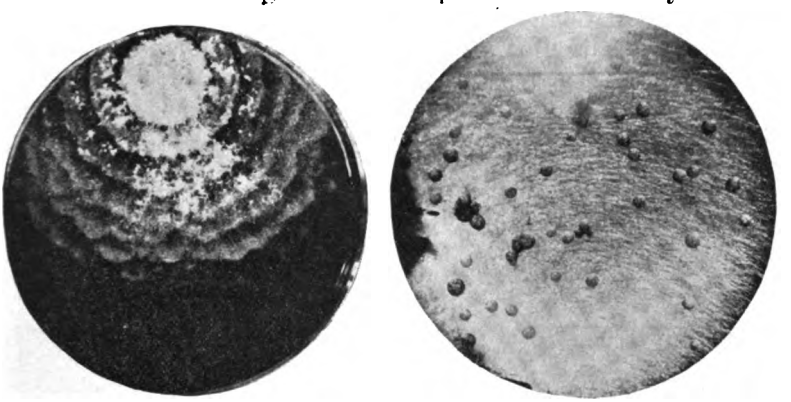

FIG. 13.—Pure culture of the fungus seventeen days old, grown upon cow-pea agar in diffuse light; pycnidia not then formed.
FIG. 14.—Pycnidia on agar plate, viewed from below.

older central portion pycnidia began to form at the end of about eight days, though often later. Pycnidial formation proceeds from the central zones to the younger zones, the pycnidia being most numerous in the denser zones, although they were by no means lacking in the lesser zones.

Upon *boiled rice,* in test tubes, the fungus grew luxuriantly. As the threads first invaded the rice there was developed a salmon color, which later turned to black.

Upon *boiled corn,* in test tubes, the mycelium developed well, became black, and pycnidia were present in abundance at the end of eleven days.

The most striking features noted in these nutrition studies was the influence of starch and glucose in agar or the starch of the rice or corn media in causing the development of an intense black coloration in the mycelium. Also the unfavorable influence of peptone, beef and gelatine as evidenced by distorted mycelium and the failure to develop pycnidia.

The *formation of zones* is the most characteristic feature of growth of this fungus upon clear, solid media. (Fig. 14.) Reference has

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constantly been made to this feature. The lesser zone, the zone which immediately surrounds the point of inoculation, is due to the mycelium rapidly growing out in every direction in the medium from the point of inoculation. As each individual thread becomes more and more distant from the center and has made more and more branches, the threads begin to crowd each other much more closely until, if conditions be proper, a time is reached when apparently the crowding becomes so great that further growth in length is inhibited. There then occurs a development of aerial hyphæ and a thickening and darkening of the ends of hyphæ already produced; this resulting in a darker zone surrounding the lighter zone. After maintaining this condition for some time, individual threads, in a scattered fashion, break through the outer dense zone, continue their growth and proceed to the formation of a second lesser zone, followed in course of time by a second denser zone, all being formed in precisely the same fashion that the first two zones were made. Plates have been exposed under different light relations and different temperatures, and it seems probable that there is no connection between either of these factors and formation of zones in this fungus, other than is occasioned by increasing or decreasing growth.

INOCULATIONS. (Figs. 15, 16 and 17.)

FIG. 15. Four diseased heads produced by inoculation from pure culture.

Some forty inoculations were made with mycelium taken from pure cultures on bits of agar. Of these twenty-eight gave positive results. Control cultures remained uninfected. Inoculations were made within the involucral scales, between the flowers in the head, on stems, and on leaves, as follows:

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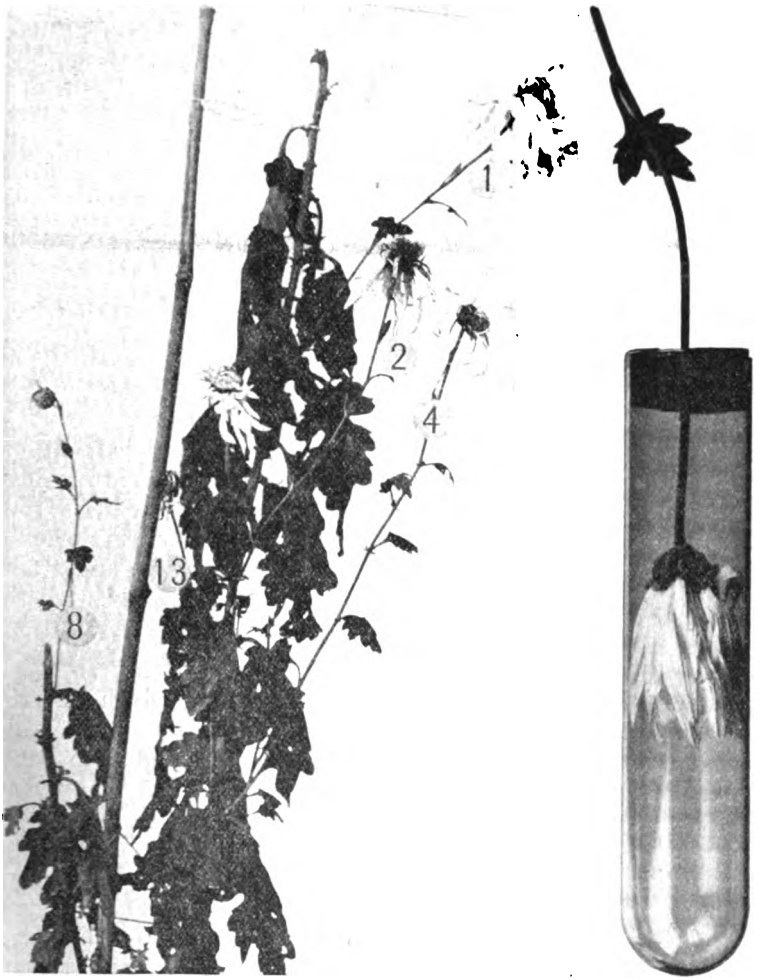

IG. 16.—Showing method of covering inoculated heads to supply humid atmosphere.
FIG. 17.—Plant bearing flowers in condition of disease; produced by inoculation: 1, The topmost head inoculated between the flowers with pycnidia from agar. 2, The second tallest head as in No. 1. 4, Inoculated on scarified bark immediately below the head Dates as above. 13, Inoculated November 20 inside involucre, covered by tube twenty-four hours; diseased December 8. 8, Inoculated November 24 with agar on scarified bark under wet cotton; diseased December 10.

SERIES I.

Inoculated from mycelium obtained from the original agar plate culture on which diseased rays had been placed. Inoculations made November 22, 1906.

Inoculation No. 1—under the involucre of the bud, which was just beginning to open. Observed December 8, growth; December 18, exhibited typical disease.

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Inoculation No. 2—in the axil of the uppermost bract, in needle pricks, with agar. The bud above was just beginning to open. Examined on December 8 and December 18 with no indication of disease.

Inoculation No. 3—with mycelium upon agar upon the end of the unopened bud. Examined December 8, no growth; examined December 18. Typical disease.

Inoculation No. 4—control cultures similar to No. 3, with sterile needle. Examined December 8 and December 18. No growth.

Inoculation No. 5—at base of leaf; the tissue unbroken. Examined December 8 and December 18. No result.

Inoculation No. 6—agar laid upon the outside of the involucre; tissue uninjured. Examined December 8 and December 18. No result.

Inoculation No. 8—same as in No. 6. Same results.

Inoculation No. 9—at the base of the petiole. Tissue uninjured. Examined December 8 and December 18. No result.

Inoculation No. 10—leaf base pricked and inoculated with agar culture. Examined December 8 and December 18. No result.

It is to be noted that in this series Nos. 1 and 3 produced typical disease; that is, all of the inoculations which were attempted within the involucre. Control inoculations produced no growth and attempts to produce the disease upon leaves and stems through uninjured tissue failed.

SERIES II.

Inoculated November 24, 1906, with mycelium, which was richly set with pycnidia.

Inoculation No. 11—agar bearing mycelium placed deep between the petals of the open flower. Examined December 8. Showed typical disease.

Inoculation No. 12—same as No. 11.

Inoculation No. 13—same as No. 11, using sterile agar; control inoculation. Examined December 8 and December 18. No growth.

Inoculation No. 14—peduncle immediately below the bud scarified. Inoculated with mycelium on agar. Examined December 8. Showed typical disease.

Inoculation No. 15—similar to No. 14, but with sterile agar. Control experiment. Examined December 8 and December 18. No growth.

Inoculation No. 16—upon scarified stem immediately under head with agar bearing mycelium, the whole covered with wet cotton. Examined December 8 and December 18. No result.

Inoculation No. 17—conditions same as in 16. Examined December 18; head typically diseased.

Inoculation No. 18—conditions same as in 16. Examined December 8, no result; examined December 10, typical disease.

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Inoculation No. 19—agar bearing mycelium placed upon the tip of the opening head. Examined December 8, no growth; December 18, typical disease.

Inoculation No. 20—conditions same as in No. 19. Examined December 8; typical disease.

Inoculation No. 21—condition same as in 19; lost through accident.

It is to be observed that in this series the inoculations within the flower produced typical disease. Control inoculations produced no disease. Inoculation upon scarified stem when covered with damp cotton to prevent evaporation was capable of inducing the disease.

Series III.

Inoculated November 29, 1906.

Inoculation No. 22—agar bearing mycelium was placed between the rays of a head and the whole covered with a tube and supplied with wet cotton to prevent evaporation; tube and cotton were removed the next day. Examined December 8, showed typical disease.

Inoculation No. 23—similar to 22, but inoculations made just inside the involucre. Examined December 8 showed typical disease.

Inoculation No. 24—similar to 22, but upon the tip of the bud. Covering tube removed after two days. Examined December 8 showed typical disease.

Inoculation No. 25—a single ray from a diseased flower was placed among the rays of a flower just beginning to open. They were left uncovered. Examination December 8 showed typical disease.

Inoculation No. 26—similar to 25. Covered with tube as in 22. Examination December 8 showed typical disease.

Inoculation No. 27—similar to 22. Examination December 8 showed typical disease.

From inoculations Nos. 22, 23, 24 and 27 it seems evident that the protecting of the inoculations for 24 or 48 hours from evaporation leads to greater certainty and rapidity of infection. Inoculations Nos. 25 and 26 go to show the lack of necessity for any covering when diseased rays are used with which to inoculate. It is possible that the mycelium is in a more vigorous condition in such diseased rays.

Series IV.

Inoculations made November 30, 1906, from very vigorously growing mycelium from a plate of cowpea agar.

Inoculations 28 to 31—made from the extreme tip of the mycelium taken from the edge of the colony. Inoculation made under the outer rays. Examination December 8, no growth; examination December 18, all show typical disease.

Inoculations 32 to 35—inoculating material taken from the youngest dense zone in the colony. Inoculated as in 28 to 31. Examina-

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tion made December 8, no growth; examination December 18, all typically diseased.

Inoculations 36 to 40—inoculating material taken from the center of the colony. The agar being full of old dark, thick hyphæ. Examined December 8, all showed typical cases of disease.

It seems apparent from this series that the mycelium from the older central portions is capable of producing quicker infection than that from the outer region of the colony.

RECOVERY OF FUNGUS FROM INOCULATED HEADS.

In many cases rays were taken from the heads which were made diseased by inoculations, and these rays were thrown upon Petri dishes containing solidified pea agar, with the result that in each case the petal was soon the center of a pure colony of the fungus identical with that used in the inoculation.

As the result of all of these inoculations it seems clear that the fungus in question is actually the cause of the diseased condition of the blossom; that it can gain entrance to the tissue of the blossom much more easily than to the tissue of the leaves, petioles and stems, and that humidity at the time of inoculation favors the success of the inoculations.

I desire to acknowledge my indebtedness to J. G. Hall, Assistant Pathologist, for the illustrations accompanying this article.

Media Used.

Cowpea Agar.—Five hundred grams of fresh cowpea pods and contents were stewed in one litre of water for one-half hour, drained, 1 per cent agar added, autoclaved at 110° C. and filtered.

Cowpea Leaf Agar.—Five hundred grams of cowpea leaves and petioles were stewed in one litre of water for one-half hour, drained, 1 per cent agar added, autoclaved at 110° C. and filtered.

Pea Agar.—Ten garden peas were autoclaved with one litre of water for one-half hour, drained, 1 per cent agar added, autoclaved at 110° C. and filtered.

Four Per Cent Pea Agar.—Four per cent by weight of dry peas were stewed with one litre of water for one-half hour, drained, 1 per cent agar added, autoclaved at 110° C. and filtered.

Standard Beef Agar.—According to the rules of the American Public Health Association.

Standard Beef Gelatine.—According to the rules of the American Public Health Association.

Pure Agar.—Agar without addition of nutrients, 1 per cent agar to one litre of water.

Litmus-lactose Agar.—Standard beef agar with the addition of 1 per cent lactose and litmus sufficient to color.

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Lettuce Agar.—Ten grams of lettuce leaves and petioles were stewed in water for one-half hour, drained, 1 per cent agar added, autoclaved at 110° C. and filtered.

Boiled Rice.—Two grams of washed rice to 8 cc. of water, tubed, autoclaved at 110° C.

Boiled Corn.—Two grams of washed corn to 8 cc. of water, tubed, autoclaved at 110° C.

Glucose Agar and Starch Agar.—Made by adding percentages indicated to pure agar and sterilizing intermittently.

Peptone Agar.—By adding per cent indicated to pure agar and autoclaving at 110° C.

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THE EFFICIENCY OF PURE CULTURE INOCULATION FOR LEGUMES.

BY F. L. STEVENS AND J. C. TEMPLE.

HISTORICAL.

The knowledge that legumes enrich soil is very old, and many references to that power occur in ancient writings. Pliny[1] and Varro[2] both refer to this fact. Root tubercules are said to have been seen as early as 1586.[3] They were described by Malpighi[4] in 1687, yet that this enrichment is dependent upon the presence of the tubercle upon the roots was first made evident by the classical experiments of Hellriegel and Wilfarth about 1886.[5] The conclusions of these pioneers were completely verified by many other workers between 1888 and 1895. Bacteria were first seen in legume root tubercles in 1866 by Woronin.[6] Experiments by Hellriegel[5] in 1886 also proved that the tubercles can not develop in sterile soil, but that if an infusion from a soil in which peas have previously grown be added to sterilized soil, the tubercle will then develop normally. Ward[7] later saw bacteria enter the root hairs and root tubercles develop at this point of infection. In 1888 Beyerinck[8] isolated and cultivated the root tubercle organism upon artificial media. In 1890 Prazmowski,[9] and since then many other experimenters have produced the nodules by laboratory inoculations with pure culture of the root tubercle organism. Since it was definitely shown that the tubercles are due to bacteria, and that the value of the legume crop is dependent upon these tubercles, it has been the constant aim of bacteriologists to devise some successful means of inoculating the germ into field soils that are in such need.

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[1] A very complete historical resumé of this question may be found in Cent. f. Bak. Par. u. Inf. II, 18 289, by Dr. Gino de'Rossi.
[1] Historia naturalis, LVIII.
[2] De re rustica, I. 23.
[3] Delechamps, Historia generalis plantarum.
[4] Opera omnia. Anatomia Plantarum. Pars II. De gallis.
[5] Hellriegel Welche Stickstoffquellen stehen der Pflanzen. zu. Gebote (Tageblatt der 59, Vers. d. Nat u. Aerzte in Berlin, 1886,) and Hellriegel and Wilfarth. Untersuchungen über die Stickstoffnahrung der Gramineen und Leguminosen (Beilageheft zu der Zeit. des Vereins für Rubenzuckerindustrie des Deutschen Reiches.) Berlin, 1888.
[6] Mem. d. P. Acad. dup. d. Sciences, St. Petersburg VII, 1866, 2.
[7] Phil. Trans. Roy. Soc. London 178, 1887.
[8] die Bakterien der Papilionaceenknollchen. Bot. Zeit., 1888.
[9] Landw. Versuchst. 1890, 37 161.

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Field Inoculations.

Many successful field inoculations have been made into soil deficient in root tubercle bacteria. Salfeld[1] in Germany in 1887, Fruwirth[2] of Germany in 1893, Schniftes[3] of Germany in 1894, Otis[4] of Kansas in 1898, Duggar[5] of Alabama in 1897, made inoculations by using for such purpose soil that had previously produced good crops of legumes.

Objections to Soil as Medium for Inoculation.

The efficiency of soil in which appropriate legumes have grown as a medium for inoculation is unquestioned. It possesses, however, certain disadvantages.

1. It is heavy and cumbersome and therefore expensive to transport to any distance in quantity sufficient for extensive use.

2. Unless due care be exercised there is danger of transporting at the same time seeds of noxious weeds; particularly is this true in the case of clovers or alfalfa, which may be infested with dodder.

3. There is great danger, especially in the Southern States, of carrying infective material of some of the many serious, invincible soil diseases, such as the wilts of cotton, cowpea, tobacco or melons. There is danger of conveying nematodes, which cause the root knot on so many crops in Southern soils.

When Inoculation is Necessary or Desirable.

Extravagant claims have been made by some who are interested in selling material with which to inoculate. Soil inoculation is by no means always necessary or even beneficial. Inoculation is desirable and highly beneficial when the germ appropriate to the crop plant is absent from the soil, e. g., in regions where alfalfa has not been grown, it is often necessary to inoculate with alfalfa soil in order to secure tubercles and a good yield. Similarly where cowpeas have not been grown, cowpea soil can be used to advantage. Where cowpeas or alfalfa now grow successfully or in a region where they will grow successfully with tubercles in plenty upon their roots, inoculation is unnecessary.

The advisability of inoculation is indicated in the case of any leguminous crop, where the crop in question fails to produce tubercles properly upon any given field.

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[1] Storer's Agriculture II., 1897, 105.
[2] Deut. Landw. Presse XVIII, 127, cited by Chester Bull, 98 Pa. Dept. of Agriculture, 1902.
[3] Cited by Chester.
[4] The Industrialist, Kan. Ag. Col., 24, 1898, 363.
[5] Ala. Exp. Station Bull., 76.

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Inoculation by Pure Cultures.

As stated above, pure cultures have been many times used in laboratory inoculations, and repeated attempts have been made to extend their use to the field. Nobbe and Hiltner, in 1896, prepared pure cultures of the root tubercle organisms, which were placed on sale under the commercial name of Nitragin. This substance was extensively tried in Germany and America. In many instances there was marked benefit from its use, and in many other cases no benefit resulted. The frequent failure to benefit may be partially attributed to the use of Nitragin on soils already well inoculated, and therefore not in need of inoculation. In part, also, it was probably due to a variation in vigor or vitality of the cultures. Probably many cultures when used were no longer alive. In any event, Nitragin fell into disuse.

Another attempt to attain the ideal distribution of pure cultures of the root tubercle organism in form suitable for practical field inoculation, was made by workers in the United States Department of Agriculture, and the goal was thought to have been reached. It was claimed that not only were these workers able to cultivate the organism (as many had done before), but that they were able by special methods to increase its nitrogen gathering efficiency, and further, that they were able to successfully distribute their cultures of bacteria, of heightened virulence, in dry form upon cotton so as to be of practical use to the farmer. The claims seem to have been prematurely set forth, possibly hastened by an unfortunate magazine or newspaper notoriety. Results have shown that notwithstanding the frequent success in the use of such cultures they can not be depended upon with such certainty as to warrant their general use, and this method of distributing the germ has been discontinued by the Bureau originally issuing the cultures and another substituted in its stead.

The Method of Liquid Cultures.

The present method of the United States Department of Agriculture consists in the issuance of cultures in liquid, hermetically sealed in glass. With the history of inefficiency and unreliability of the method of distribution of cultures in dried form upon cotton in mind, it was deemed wise to make a test of the present method. To this end cultures were received through the courtesy of the National Bureau of Plant Industry. These cultures were received in May, 1906, and the labels indicated that the alfalfa, vetch, Canada field pea and red clover were to be used before July 1st, the sweet pea and bean before July 15th. None were marked with earlier dates of limit of utility.

Viability of the Liquid Cultures.

In order to ascertain the approximate number of living bacteria in the liquid cultures of bean, cowpea, Canada field pea, sweet pea, red

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clover and vetch, the cultures were opened with precautions to avoid contamination or injury on May 28, 1906, and one cubic centimeter withdrawn with a sterile pipette. This was diluted with sterile water to 1 to 100, 1 to 1,000 and 1 to 10,000, and plated in standard beef agar at a temperature below 45° C. Count of the colonies was made on the third and seventh days with the following results:

NUMBER OF BACTERIAL COLONIES.

Culture used.	Third Day.				Seventh Day.			
	Number on Plate.			Number per c.c.	Number on Plate.			Number per c.c.
	1 to 100	1 to 1,000	1 to 10,000		1 to 100	1 to 1,000	1 to 10,000	
Alfalfa	Too many to count	490	0	490,000	Too many to count	800	0	800,000
Bean	174	4	0	17,400	176	4	2	176,000
Cowpea	0	0	1	0	0	0	1	0
Canada field pea	Too many to count	1,150[1]	65	1,150,000	Too many to count	1,100[1]	74	1,100,000
Sweet pea	0	0	0	0	0	0	0	0
Red clover	1	0	0	0	1	1	0	0
Vetch	0	0	0	0	0	0	2	0

[1] Estimated.

It seems clear from this table that the cultures of cowpea, sweet pea, red clover and vetch were sterile, while alfalfa, bean and Canada field pea contained germs in abundance. It is to be noted that there is no correspondence between the presumable age of the culture as indicated by its label and the prevalence of germs in it.

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The colonies which did appear were quite uniformly one species and seemed to be those characteristic of the root tubercle organism, though through the pressure of the other work no further laboratory study was made of the organism.

Purity of the Cultures After Multiplication.

A portion of the contents of each tube which was tested, as recorded in the last paragraph, was placed in water, with the nutrient salts furnished us with the cultures, precisely as indicated and in the proportions indicated in the printed slip of directions accompanying the cultures, with the exception, however, that the utensils employed were much cleaner than would ordinarily be used in farm practice. At the end of two days, the time indicated in the directions for their use, these multiplying cultures were in violent fermentation, and microscopic examination revealed the presence of many species of bacteria and yeasts, as well in those which plating had shown to be sterile as in those which originally possessed bacteria. The evidence was that these multiplying cultures were seriously and grossly contaminated. Whether the root tubercle organism in such cases as they were alive could survive the severe competition occurring in such a contaminated, mixed culture is a serious and practical question.

Pot Experiments.

The practical question is whether these liquid cultures can be depended upon to produce tubercles upon appropriate legumes in soils devoid of root tubercle bacteria. To test this point, the following experiments were planned and carried out.

A soil consisting of equal parts of sand and red clay, well mixed and sifted through a sieve of one-sixteenth inch mesh, was weighed into six inch flower pots, 1,500 grams to each pot. Half of the pots was sterilized by heating for one hour in the autoclave at 120°, the remaining half was not sterilized. The pots were arranged in series of five each, and each series was supported in a separate wooden trough, out of contact with others. In the case of inoculated pots, all in a given series were treated with the same culture.

The series comprised the following combinations, each in sterile and non-sterile soils, and each series consisting of five separate pots:

Cowpea + cowpea organism.
Cowpea + 0 organism.
Cowpea + vetch organism.
Cowpea + bean organism.
Cowpea + alfalfa organism.
Canada field pea + Canada field pea organism.
Canada field pea + 0, organism.
Canada field pea + cowpea organism.
Canada field pea + vetch organism.
Canada field pea + alfalfa organism.
Canada field pea + sweet pea organism.
Vetch + vetch organism.
Vetch + 0 organism.
Vetch + cowpea organism.
Vetch + bean organism.
Vetch + alfalfa organism.
Alfalfa + alfalfa organism.
Alfalfa + 0 organism.
Alfalfa + cowpea organism.
Alfalfa + vetch organism.
Alfalfa + bean organism.
Sweet pea + sweet pea organism.
Sweet pea + 0 organism.
Sweet pea + Canada field pea organism.

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All seeds were treated for two hours with 4 per cent formalin to kill any ordinary root tubercle organism present. Three modes of inoculation were employed: (1) Upon the surface of the soil in pot 1 was poured a portion of the culture just as received from Washington, indicated in the table as "direct." (2) To pots 2 and 3 were added portions of a multiplying culture made by following as precisely as possible the printed directions accompanying the culture, indicated in tables, as "according to directions." (3) To pots 4 and 5 were added portions of the multiplying culture mixed with a small quantity of soil, indicated in tables as "Mixed with soil." All inoculations were made at the time plants showed above soil.

Since the soil was very poor in nutriment, food materials, omitting nitrogen, were supplied by an application of a modified Knop solution.[1] During the growing period 300 cc. was added to each pot. The pots were watered daily with tap water unless the rainfall was ample. Toward the close of the growing season the plants were carefully removed from the pots, the earth washed away, great care being taken to loosen no tubercle, and the tubercles that had developed in each pot were counted and recorded. The results of these inoculations are exhibited with comments below:

TABLE 1.—Showing Number of Tubercles in Sterile Soil Inoculated with Germ Appropriate to the Plant.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.	Pots 4 and 5 Mixed with Soil.	Total.	Average.
22a, Sweet pea + sweet pea	0	0 0	0 0	0	0
17a, Alfalfa + alfalfa	0	7B[2] 1B	0 10	18	3 +
12a, Vetch + vetch	0	0 0	0 21	21	43 +
1a, Cowpea + cowpea	17T	54B 0	60B 7T	138	27
6a, Canada field pea + Canada field pea[3]	-----	---- ----	---- ----	56	------
				233	

TABLE 2.—Showing Number of Tubercles in Sterile Soil Uninoculated.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.	Pots 4 and 5 Mixed with Soil.	Total.	Average.
23a, Sweet pea + 0	0	0 110B	60B 31B	102	20 +
18a, Alfalfa + 0	0	0 1	0 0	1	1
13a, Vetch + 0	0	6 0	0 0	6	1 +
2a, Cowpea + 0	3	12 2	38TB 30TB	85	17
7a, Canada field pea + 0 All methods	-----	---- --	---- ----	50	10
				244	

[1] Water 1000 cc., calcium phosphate, calcium sulfate, potassium sulfate, magnesium sulfate, one gram each, iron chloride, trace.

[2] B signifies that most of the tubercles were of the bottom of the pot, near or outside of the drainage opening. T indicates that most of them were at the top of the soil.

[3] In the case of the Canada field pea the number of tubercles from each pot was not kept, the total only being recorded.

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On comparing Tables 1 and 2 it is seen that by using sterile soil the only significant gain from inoculation was in the case of cowpeas, the average rising from 17 uninoculated, to 27 inoculated. In both instances the majority of the tubercles were at either the bottom or the top of the pot, therefore presumably from aerial infection from the adjoining fields, which are known to be thoroughly inoculated with the variety of germ appropriate to this plant. The abundance of nodules on the uninoculated, sterile, sweet pea pots is due to the same cause, aereal infection, the nodules nearly all being at the bottom of the pot. There is no essential difference between the pots, due to the different modes of inoculation employed.

TABLE 3.—Showing Number of Tubercles in Non-Sterile Soil Inoculated with Germ Appropriate to the Plant.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.		Pots 4 and 5 Mixed with Soil.		Total.	Average.
17b, Alfalfa + alfalfa	55	10	9	8	----	82	20
12b, Vetch + vetch	100	100	35	60	50	345	69
6b, Canada field pea + Canada field pea	-----	----	----	----	----	55	5
1b, Cowpea + cowpea	11	50	20	30	60	171	34 +
						653	

TABLE 4.—Showing Number of Tubercles in Non-Sterile Soil Uninoculated.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.		Pots 4 and 5 Mixed with Soil.		Total.	Average.
18b, Alfalfa + 0	20	12	55	10	36	133	26 +
13b, Vetch + 0	70	68	60	40	35	273	54 +
7b, Canada field pea + 0	----	----	----	----	----	80	8
2b, Cowpea + 0	30	47	66	50	52	245	49
						741	

From Tables 3 and 4, experimenting upon non-sterilized soil, there is no significant increase in the number of tubercles from inoculation. The vetch roots bore slightly more when inoculated, and the cowpea roots more when not inoculated. Both variations were small and inoculations were doubtless without effect. There is no real difference in the results from different modes of inoculation.

TABLE 5.—Showing Number of Tubercles in Sterile Soil.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.		Pots 4 and 5 Mixed with Soil.		Total.	Average.
21a, Alfalfa + bean	1	0	4	1	0	6	1 +
20a, Alfalfa + vetch	0	2	0	0	0	2	.05
19a, Alfalfa + cowpea	0	1	2	1	1	5	1
						13	

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TABLE 6.—Showing Number of Tubercles in Non-Sterile Soil.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.		Pots 4 and 5 Mixed with Soil.		Total.	Average.
21b, Alfalfa + bean	33	14	21	45	23	136	27 +
20b, Alfalfa + vetch	35	45	41	40	25	186	37 +
19b, Alfalfa + cowpea	16	24	30	16	9	95	19 +
						417	

Tables 5 and 6 indicate clearly that the germ needed for alfalfa was present in the soil employed and that inoculation with the bean, vetch or cowpea organisms was ineffective in producing tubercles. Compare also the alfalfa entry of Tables 1 and 2, showing that the alfalfa germ was no more effective than any of the other germs for the alfalfa plant. The close agreement between the individual alfalfa pots lends strength to these conclusions and indicates that none of the various methods of inoculation employed are effective.

TABLE 7.—Showing Number of Tubercles in Sterile Soil.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.		Pots 4 and 5 Mixed with Soil.		Total.	Average.
16a, Vetch + alfalfa	22	87B	0	72T	----	181	45 +
15a, Vetch + bean	37B	49B	35B	3B	1	125	25
14a, Vetch + cowpea	0	25B	66B	8B	0	99	19 +
						405	

TABLE 8.—Showing Number of Tubercles in Non-Sterile Soil.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.		Pots 4 and 5 Mixed with Soil.		Total.	Average.
16b, Vetch + alfalfa	90	57	85	35	37	304	60 +
15b, Vetch + bean	35	45	110	63	32	285	57
14b, Vetch + cowpea	36	55	40	26	45	202	40 +
						791	

Tables 7 and 8 show a decidedly larger number of tubercles on the non-sterile soil. The few that were present in the sterile pots were at the top or bottom and hence were derived presumably by aereal infection. These tables indicate that the bean, cowpea and alfalfa cultures were ineffective on vetch.

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TABLE 9.—Showing Number of Tubercles in Sterile Soil.

Plant Used and Organism Added.	All Methods	Average.
11a, Canada Field Pea + sweet pea	0	0
10a, Canada Field Pea + alfalfa	0	0
9a, Canada Field Pea + vetch	10	2
8a, Canada Field Pea + cowpea	26	5+

TABLE 10.—Showing Number of Tubercles in Non-Sterile Soil.

Plant Used and Orgaanism Added.	All Methods	Average.
11b, Canada field pea + sweet pea	134	26+
10b, Canada field pea + alfalfa	20	4
9b, Canada field pea + vetch	48	9+
8b, Canada field pea + cowpea	85	17

Tables 9 and 10 indicate a lack of efficiency of the various cultures to produce nodules on the Canada field pea, while the great number of tubercles in the non-sterilized pots shows the presence of the organism in the soil employed.

TABLE 11.—Showing Number of Tubercles in Sterile Soil.

Plant Used and Organism Added.	Direct.	According to Directions.	Mixed with Soil.	Total.	Average.
5a, Cowpea + alfalfa	4	80^{B} 7	---- 3	94	23.5
4a, Cowpea + bean	16^{B}	86^{TB} -----	27^{T} 10	134	34+
3a, Cowpea + vetch	-----	21 90^{40B}	65^{30B} 38^{30B}	213	53+
				447	

TABLE 12.—Showing Number of Tubercles in Non-Sterile Soil.

Plant Used and Organism Added.	Direct.	According to Directions.		Mixed with Soil.		Total.	Average.
5b, Cowpea + alfalfa	21	75	56	35	35	222	44+
4b, Cowpea + bean	86	69	36	85	25	316	60+
3b, Cowpea + vetch	60	55	55	46	74	290	58
						828	

Tables 11 and 12 indicate lack of effectiveness of the cultures. Table 11 shows aereal infection.

From a general summary of all the tables we find the following:

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	Number of Tubercles per Pot.
Sterile Soil appropriately inoculated	9.32
Sterile Soil not inoculated	9.76
Non-sterile soil inoculated	34.98
Non-sterile soil not inoculated	37.05
Pot No. 1 inoculated direct	24.18
Pots Nos. 2 and 3 inoculated according to directions	33.22
Pots Nos. 4 and 5 inoculated by soil	24.39

It seems throughout these tests that there is no essential difference in results from the different methods of inoculation employed. The general presence of tubercles upon all plants in non-sterile soil shows the presence of proper germs in the soils employed. There is a general lack of infection in sterile soil with alfalfa and Canada field pea, indicating a relative rarity of those germs in the air. These crops are not grown in the immediate vicinity.

There are many tubercles even in sterile soil on vetch and cowpea, due to aereal infection of the soil. This indicates an abundance of these organisms in the air. These plants grow in abundance in adjoining fields.

The abundant aereal infection of these two crops, which are commonly grown here, and the slight aereal infection of crops not grown here, points strongly to the varietal independence of the organisms, to the special adaptability of the organisms to special crop plants.

SUMMARY.

The facts as detailed are—

That many of the cultures when received were devoid of live organisms of any kind, as is shown on page 50.

That in multiplying the cultures, even under cleanly laboratory conditions, there is gross contamination by molds, yeasts and foreign bacteria. (See page 51.)

That in the pot experiments there was rarely any increase in the number of tubercles due to inoculation. The cultures here used were obtained directly from the National Department of Agriculture, and were fresh. They were probably of as good quality as is to be obtained and were presumably superior to the commercial cultures upon the market.

While the number of tests here recorded is not large, it is to be noted that these tests were made under circumstances highly favorable to the cultures, and it is a reasonable supposition that failure would be more liable to occur in actual farm practice than in these pot tests.

It therefore appears that the method of inoculation with liquid cultures, as at present prepared, is uncertain and unreliable, and not to be recommended as a substitute for the method of inoculation with soil containing the appropriate organisms.

NOTE.—Since writing the above, Farmers Bulletin 315, "Progress in Legume Inoculation" of the U. S. Department of Agriculture has come to hand, and our conclusion that inoculation by liquid culture is not reliable, seems to us to be supported by the fact appearing in that bulletin since out of 4296 inoculations made by farmers in many sections of the United States 2087 were of doubtful results and only 1770 were successes, or less than 50 per cent. We wish again to emphasize the dangers of inoculation by soils as set forth above (page 48) and on page 14 of Farmers Bulletin 315 and to call attention to the necessary precaution of knowing the origin of the soil to be employed for inoculation purposes.

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NOTES ON PLANT DISEASES OCCURRING IN NORTH CAROLINA.

By F. L. STEVENS and J. G. HALL.

Alfalfa; Dodder (*Cuscuta*) was reported as bad in Mecklenburg County. This disease has been reported from Jackson and Orange counties as well.

Apple, the Fly Speck, and the Sooty Mold are very prevalent on nearly all apples exhibited for sale on the Raleigh markets, making them extremely unsightly and diminishing their market value.

Apple Root Rot (*Clytocybe*).—This toad stool, growing upon the roots of apple trees, caused their death in Haywood County, being especially bad in young orchards.

Apple Blight (*Bacillus*) is prevalent throughout the State. It has now been recorded from more than half the counties of the State. It was noted in especially severe form this year in Transylvania County.

A very destructive outbreak in a rather unusual form also occurred at Waynesville, Haywood County. In an orchard of eighty trees nearly forty were seriously attacked. In some instances the tip of the twig died from the end backward with a blackening of the cambium. The most common symptom, however, was a blackening of the bark in the crotches of the branches, which was of such nature as to call forth the comon name, "the dry rot," from the owner. The blackening characteristic of the bark prevailed to a distance of several inches from the point of infection. So abundant were the diseased spots on the trees that the trees were deemed worthless. Microscopic examination revealed cells full of the characteristic bacilli.

Apple Fire Blight, followed by *Sphæropsis* and *Coniothyrium*.—Several specimens have come to hand this year, notably from Rutherford and Vance counties, which have all the appearance of being typical fire blight. The bark was shriveled and hard in the affected portions; the boundary between the diseased parts and healthy parts was sharp, and longitudinal cracks were apparent there, due to the unequal tension caused by the continued growth in the healthy bark. The cambium and often the wood was blackened in the manner characteristic of this disease.

Unlike the ordinary fire blight these twigs were thickly set with pycnidia. These pycnidia proved, upon examination, to be in many instances Sphæropsis, and in many other instances Coniothyrium, while occasionally other fungi were present. The most frequent pycnidial forms, however, were Sphæropsis and Coniothyrium. Upon close examination it seemed apparent that the death of the twig was caused by the usual fire blight, and these other fungi followed almost immediately as saprophytes upon the dead twig.

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The presence of these two fungi in such abundance upon the twigs is significant, since it shows that twigs dead of the blight may serve as a multiplying and breeding ground for these two fungi, which are so destructive to fruit in other seasons of the year.

The fire blight is bad enough on its own account, but in the light of the facts just related it becomes doubly important to cut out and burn all of the fire blight as soon as it appears, in order to minimize the possibility of the dead twig produced by the fire blight serving to spread these other rot-causing fungi.

Apple Crown Gall has been heard of during this year from Lenoir and Rowan counties, in spite of the efforts made to prevent its distribution. It is now known in fifteen counties of the State.

Apple Black Rot (*Sphæropsis*).—A peculiar condition of this disease was noted in specimens received from Vance county, consisting of a complication of the blight with the black rot fungus. (See Apple Blight).

Apple Black Rot (*Sphæropsis*) was found abundantly upon twigs sent to the Station from Rutherford and Vance counties.

Apple (*Coniothyrium*).—This fungus was in several instances found causing a rot of the apple.

Apple (*Vollutella*).—A rot due to this fungus was collected at several points in the State.

Apple Leaf Spot (*Phyllosicta sp?*).—This disease is the worst with which the apple growers of the western section of the State have to contend. While the disease is very widespread and probably occurs in every county of the State, its damage is comparatively insignificant east of the mountain section, although specimens of it have heretofore been received from Halifax, Rockingham, Wake, Alamance and Guilford counties. It was noted this summer in a specially destructive form in McDowell, Madison, Buncombe, Henderson, Haywood, Transylvania, Jackson, Macon, Graham, Clay and Cherokee counties. This is the one disease, more than any other, that necessitates spraying of apples in the mountain section. It is fortunately comparatively easy to control by this means.

Apple, Bitter Rot (*Glœosporium*).—Complaints of bitter rot of apple were received from Polk county. It was estimated that there was thirty per cent loss there from this disease.

Apple Rust (*Gymnosporangium*).—This disease was most prevalent, as usual, in the Piedmont section. In the mountain section there is much less of it. In only one commercial orchard was much damage noted, and this was attributable to neighboring cedar trees. Some rust was noted in Jackson, Transylvania and Burke counties. The general appearance of this rust, as it occurs on the lower side of apple leaves, is shown in Fig. 18.

Apple Scab (*Fusicladium*) prevails throughout the State on unsprayed orchards.

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Asparagus Rust (*Puccinia*) was very abundant in Wake and in Warren counties.

Aster Rust (*Coleosporium*).—A rust due to Coleosporium affected cultivated asters grown in West Raleigh to a very serious extent. The under sides of the leaves become very thickly dotted with spots of spores. Shortly after the appearance of the spores the leaves shrivelled, and in many instances the plant died as a result of the attack.

Bean Anthracnose (*Colletotrichum*).—This disease prevails throughout the whole coastal section from Norfolk to Wilmington, the damage often ranging from fifty to seventy-five per cent of the crop. It develops with great rapidity on the pods after they are picked, and beans which are placed in the car in apparently healthy condition may arrive on the Northern markets badly spotted, thus greatly depreciated in market value.

Fig. 18.—An apple leaf affected with apple rust.

Bean Blight (*Phytophthora*) was noted in Wake county, the damage being, however, slight.

Beets; Leaf Spot (*Phyllosticta*) was noted on beets grown in cold frames at Wilmington. Damage was slight.

Boston Ivy.—This plant, as usual, was abundantly affected with *Phyllosticta*, the same which forms the conidia stage of the black rot of the grape.

Cabbage and Collard Yellow Side, reported from Halifax county as causing 75 per cent loss. This is very widespread in this State.

Cabbage Club Root (*Plasmodiophora*), reported from Kinston, Lenoir county, and also from Bertie and Robeson counties. It has also been reported from Franklin, Guilford and Rockingham counties.

Cabbage Black Rot (*Pseudomonas*).—Many cabbage fields in Transylvania county are deprived of their usefulness for raising cabbage through the introduction some years ago of this disease, probably through seed. The disease is spreading constantly, invading new

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ground, and is a serious menace to the cabbage raising industry of that section. The strictest care to prevent its spread must be exercised. This disease is rather widely distributed, particularly in the

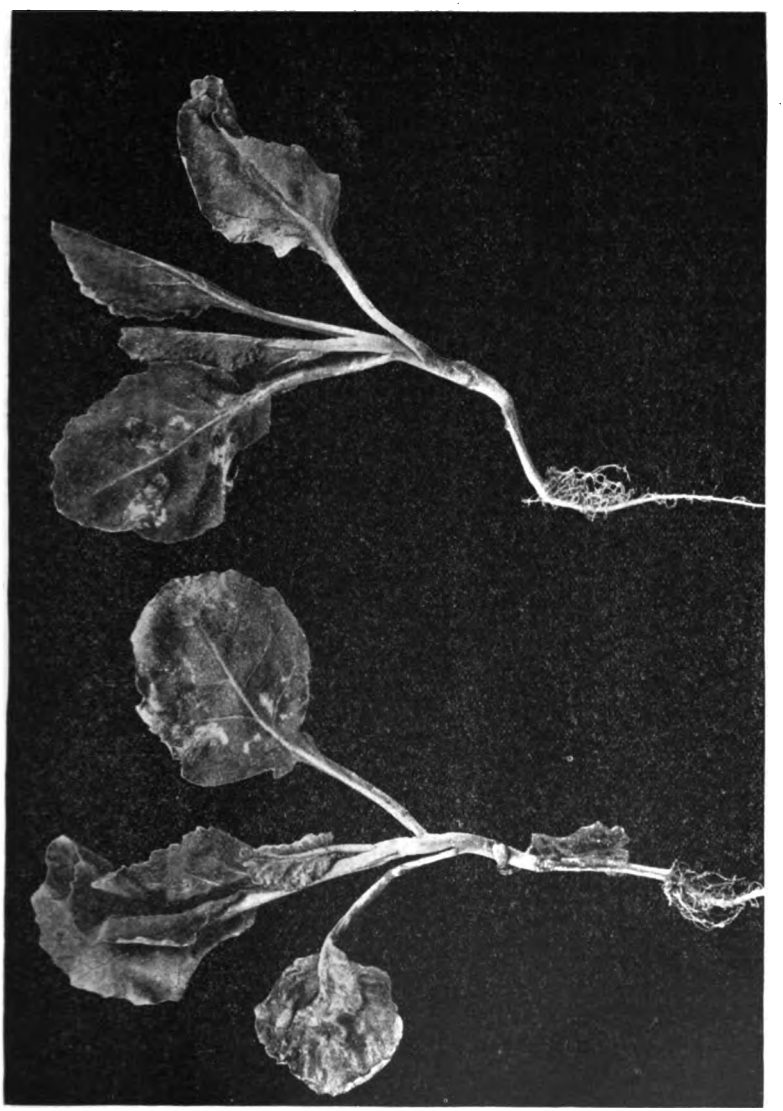

FIG. 10.—Cabbage plants affected with the downy mildew.

east, although it has not invaded, to any large extent, the regions in which cabbage are grown commercially.

CABBAGE, DOWNY MILDEW (*Peronospora*).—This is the same disease as mentioned on page 63 as affecting the collard. Specimens

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of diseased young plants, as shown in Fig. 19, were received from Fayetteville with the complaint that this disease was doing serious damage to the crop in some fields in Cumberland county. This is the first time that this disease has been noted in this State. It was first noted in the United States by Professor Halsted, who in the New Jersey Report for 1890 says the disease "was found upon the outer leaves quite generally in one large field, causing the leaves to wilt and die." The fungus was also noted in Massachusetts in the report for the same year as occurring to a considerable extent on a plot of purple topped white turnips. Halsted, in the New Jersey Report for 1894, again made mention of this fungus as abundant upon the lower leaves of young cabbage plants. It was also reported upon cabbage in Maryland in 1902 by J. B. Norton, and in the same State in 1904.[1] He says "it is bad on young plants, also on half grown cabbage." As to treatment, he says, "The Bordeaux mixture applied frequently to young plants was also very effective, together with forcing by nitrate of soda and withholding water."

CABBAGE (*Sclerotinia*).—Sick cabbage plants were received from J. B. Ingram, of Lilesville, Anson county. The plants showed in the tissue an abundance of mycelium, and upon being placed in the

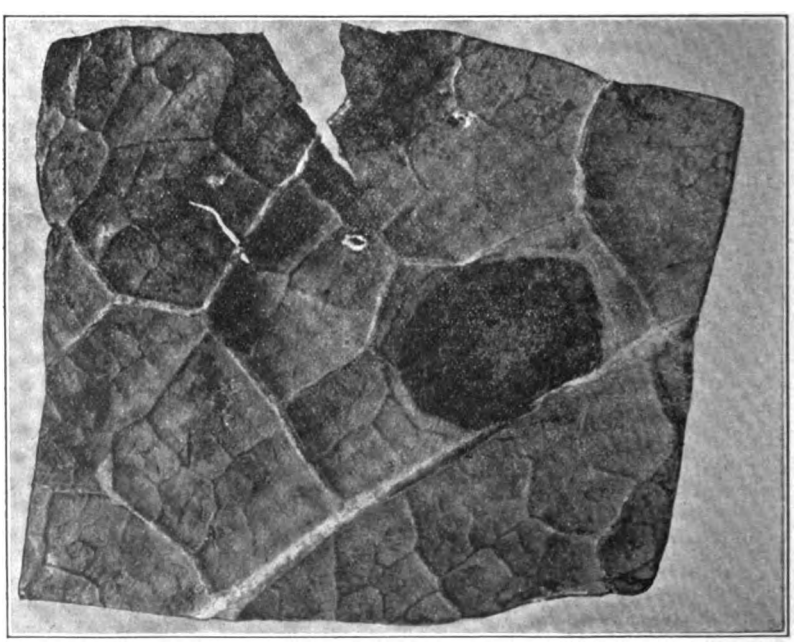

FIG. 20.—A collard black mold showing single spots more highly enlarged.

culture dish there soon developed a very luxuriant growth of white mycelium, and later sclerotia characteristic of Sclerotinia.

[1] Report of Maryland State Horticultural Society.

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CABBAGE BLACK MOLD (*Alternaria*) was sent to the Station from Lilesville by Mr. Ingram.

CANTALOUPE BLIGHT (*Alternaria*), as shown in Fig. 21, is very widespread throughout the State. Especially bad reports have been received of it from Warren, Rowan, Scotland, Cumberland and Pender counties. In Warren one grower attributed the loss of half of his crop to this disease.

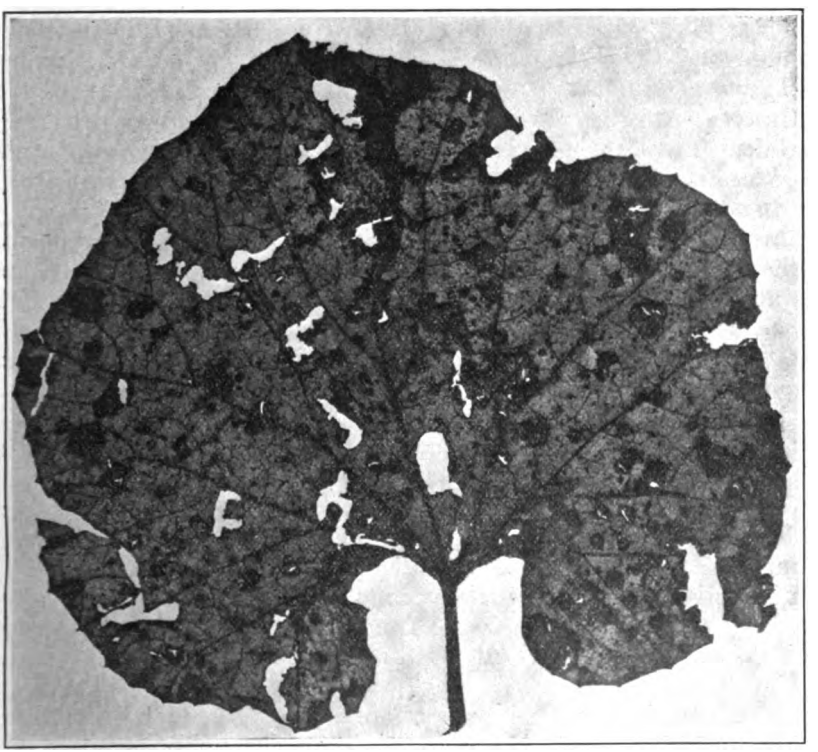

FIG. 21.—Cantaloupe leaf blight.

CANTALOUPE (*Nematodes*).—Root galls due to nematodes were very numerous in some fields in Rowan county.

CARNATION, BACTERIAL SPOT (*Stigmonose*) is very widespread and destructive.

CARNATION LEAF SPOT (*Septoria*) is noted to only a very slight extent.

CHERRY, BLACK KNOT (*Plowrightia*).—See Fig. 22. This disease was noted in specially destructive form this year in Macon, Jackson, Haywood and Wilkes counties. One correspondent writes, "The Morel cherry, once so plentiful and nice for cherry bounce, has been virtually exterminated by the black knot in many sections of the

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mountain region, and raising of cherries has been abandoned on account of this disease." See Fig. 23, page 68.

CHERRY, SHOT HOLE (*Cylindrosporium Padi*) abounds on cherry leaves to an injurious extent, principally upon neglected trees.

CHESTNUT (*Monochætia*).—The trees throughout the mountain region are largely affected with a brownish spotting of the leaves, the spots being circular, ranging in size from that of a dime to a quarter of a dollar, and usually showing concentric markings. The diseased spot was thickly beset with acervuli, bearing characteristic spores of Monochætia. The fungus seems unquestionably to be *Monochætia pachyspora* of Bubak.

CHRYSANTHEMUM, LEAF SPOT, due to *Cylindrosporium,* was very prevalent in the green-houses of Raleigh. This disease is very much more destructive upon early varieties than late varieties, as Polly Rose and Colonel Appleton.

CHRYSANTHEMUM, RAY BLIGHT.—This new disease was reported to the Station from Cumberland county, and was also found in Wake County. It was doubtless widespread upon chrysanthemums. This disease is made the subject of a separate section in this report.

CLOVER ROOT ROT, of unknown cause, is complained of in Randolph county.

COLLARD, BLACK ROT (*Pseudomonas*).—See cabbage.

COLLARD, SOFT ROT, of unknown cause, is reported as very bad in Wake and Johnston counties.

COLLARDS, DOWNY MILDEW (*Peronospora*).—In late October, 1906, collards growing in some of the gardens in West Raleigh were found to be seriously affected with the downy mildew.

This mildew manifests itself as angular spots limited by the veins, having a pale yellow appearance from above, while upon the under side there develops a growth of the spore-bearing branches of the mildew.

The diseased spots are lighter colored, pale yellow, and shrunken. On the under side of the leaf on these spotted regions is seen a fine, white down. It is from this down that the name "downy mildew" is derived.

COLLARD, BLACK MOLD (*Alternaria*).—This disease differs strikingly from the mildew, in that the affected spots are nearly black; are marked by concentric circles, are more circular and less angular than the mildew spots, and less definitely bordered, *i. e.,* they shade off more gradually into the surrounding healthy tissue.

The general appearance of this disease, as seen from the upper surface, is shown in Fig. 20. It will be noticed that in the upper surface the spot appears shrivelled. It is pale green in color. Seen from below the spot is densely black, strongly contrasting with the downy mildew mentioned above.

The black mold and downy mildew were found associated together

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upon the same plants in some gardens, and the damage was very great, in many instances resulting in the death of the plants.

Corn Rust (*Puccinia*).—This rust is widespread throughout the State, but of very slight damage.

Corn Mold.—Owing to the damp season this disease has been more damaging this year than any previous year on record.

Corn Smut (*Ustilago*) is everywhere, varying in damage probably between 1 and 5 per cent of the crop in different portions of the State. The spores of this fungus can gain entrance into the plant apparently at almost any time during the season. Seed treatment is of no avail. If all of the smut balls be cut out and burned or buried with lime each year the loss from this disease will gradually be reduced to a minimum. The question of the economy of this mode of treatment will be left to the judgment of the individual farmer. Some farmers do practice it and believe it pays. Others prefer to suffer the loss, not regarding the gain from treatment commensurate with the cost of treatment. The use of the silo will certainly accomplish the same result much more economically, since the heat normally generated in the silo is more than ample to kill the smut spores. Different portions of a corn area of a farm can in successive years be harvested into the silo, smut and all, and the smut thereby killed, thus eventually rendering the whole farm comparatively free from this disease.

Cotton, Frosty Mildew (*Ramularia Areola*) is found in nearly all cotton fields. The injury caused is not felt by the grower, though in reality the damage done per acre is probably considerable. Little is known of this disease except that it is caused by a fungus.

Cotton Wilt (*Fusarium*).—Complaints from this disease, in addition to those counties previously heard from, came from Kinston, Lenoir county, this year.

Cotton, An Unknown Disease, apparently caused by bacterium, was received from Reepsville, Lincoln county, this year.

Cotton Anthracnose (*Colletotrichum*) was received from Anson County. It has previously been troublesome in Robeson, Wake and Edgecombe counties.

Cowpeas, *Cersospora* and *Amerosporium,* prevail upon cowpeas nearly everywhere in the State, but the damage is not great.

Cowpea Wilt (*Fusarium*) was seen in an extremely destructive form in Camden and Pasquotank counties. It has since been complained of in Mecklenburg and Johnston counties.

Cucumber Blight (*Alternaria*) was destructive this year in Lenoir, Pender and Robeson counties.

Cucumber Anthracnose was complained of from Robeson county.

Figs (*Cercospora*).—This fungus is abundant upon the fig, espe-

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cially late in the season, when it causes the leaves to yellow and fall prematurely.

GRAPE, THE BLACK ROT, was seen in destructive form upon the scuppernong in Wake county. This disease prevails as usual throughout the Piedmont and mountain portions of the State upon all vines not protected by spraying. Sprayed crops were, however, raised in perfect condition.

LETTUCE MOLD (*Botrytis*) was seen in Cumberland, Duplin, Cleveland and New Hanover counties, usually to a very slight extent, though it was destructive in Duplin county. In some instances the seed bed was very badly affected with this fungus. This was notably so at Wallace this spring, plants in many places in the bed being completely killed out. This form of fungus also causes a loss to the lettuce as it approaches maturity, particularly if ventilation is not properly handled. The damage by botrytis was very slight, practically not noticeable at New Bern. There was, however, considerable of it at Fayetteville, Wilmington and Mount Olive.

LETTUCE, NEMATODES.—Abound upon the roots in the seed bed and cold frames.

LETTUCE, DROP (*Sclerotinia*), (large sclerotium form), was collected in Cumberland, Robeson, Craven and New Hanover counties, where it was exceedingly destructive, the loss ranging from 20 to 50 per cent. It prevailed this year throughout the lettuce section as formerly, being in most instances worse than in previous years. It is very rarely reported serious upon the fall crop, however, in one instance this year it seriously affected this crop, and also the seed beds.

LETTUCE LEAF SPOT (*Septoria consimilis*).—Prevails on old lettuce plants which have gone to seed, killing the older leaves and often many of the younger ones, and spotting all of the leaves of the plant. Upon the market lettuce in the beds it is usually held in moderate check, but even in the best of beds of the State many of the plants were found with the lower leaves affected and dying and the younger leaves bearing a few, though harmless spots. The death of the lower leaves from the attack of this fungus is regarded by the grower as a natural condition. It necessitates trimming before marketing, with a resulting diminution of the size of the head and a loss of market value. In some parts of the State, notably Cumberland county, this disease caused much damage in some beds, occasioning small, worthless plants.

The amount of this disease can surely be diminished in all regions by taking care that no plants are neglected and allowed to go to seed in the bed or seed bed to thus serve as a breeding place for the pest.

The disease is caused by a fungus, the spores of which fall upon the leaf, grow, penetrate the leaf and cause the bleached spot. The fungus then fruits with a small, spherical, hollow body, the pycnidium. In this body are borne countless spores to further spread the infection.

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MEDLAR, RUST (*Roestelia*) was found upon specimens of this Japanese plant grown in the park at Raleigh. The rust, in most instances, affected the fruit itself, though sometimes found upon the leaves.

MEDLAR.—This tree is also, as might be expected from its close kin to the apple, subject to the familiar apple blight, fire blight, *Bacillus amylovorus,* and the trees intended for ornaments were rendered unsightly objects.

MULBERRY, NEMATODES.—Specimens of seedlings were received from Johnston county. Upon the roots was a great abundance of small galls, which, upon examination, proved to be due to nematodes.

OATS, SMUT (*Ustilago*).—As usual prevails throughout the State except where the formalin treatment is employed. Specimens were received from Bertie and Moore counties. The estimated loss to the State this year is placed at 12 per cent of the total crop. Formalin is coming into more general use and the loss is thereby diminished.

PEA (*Ascochyta*).—Leaves of the cultivated garden pea affected with ascochyta spots, also pods affected with this spot were collected both at Goldsboro and New Bern this year. The damage under the prevailing weather conditions there this year was not serious.

PEACH *Cercospora* was collected in Rowan, Wake and Craven counties. It seems to be widespread upon the peach, but occurs chiefly in the fall, and does damage only upon young nursery stock.

PEACH, BROWN ROT (*Sclerotinia.*)—Complaints from this disease were received from McDowell county. In the peach growing section this disease is giving way to spraying.

PEACH RUST (*Puccinia pruni*) was collected at West Raleigh, Wake county, also at Craven county in the autumn. No record of real damage from this parasite has been reported from the State. Indeed we have no other record of its collection in North Carolina with the exception of one specimen collected in Wake county about two years ago.

PEACH, FROSTY MILDEW (*Cercosporella Persica, Sacc*), was very abundant throughout the year. Specimens were submitted from several portions of the State. The disease is widely spread and often serious. There is no record of its injuring orchards that are well cared for and properly sprayed. It occurs chiefly on neglected trees or young stock. Specimens of this disease were received from Rowan and Wake counties. Proper spraying will hold it in check.

PEACH YELLOWS.—Specimens of this serious disease were received from Buncombe county. With the exception of Tryon and Saluda, these are the only specimens known to be taken in this State. This is one of the worse peach diseases and every precaution should be taken against its spread.

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PEANUT *Cercospora* was collected from Wake and Duplin counties.

PEAR BLIGHT (*Bacillus*) (Fig. 22).—The pear blight has been exceedingly bad this year, worse than ever before observed in the

FIG. 22.—Pear blight: a, healthy twig; b, characteristically diseased twig.

State, and letters have been received from all parts of the State inquiring concerning the cause and anture of this disease. In several

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instances complaint has been made that even the Keiffer and Leconte have been blighted so badly as to kill whole orchards.

Especially does it seem to have been troublesome this year in Moore and Rowan counties.

PLUM POCKETS (*Exoascus*).—One case was noticed in Wake county.

PLUM, BROWN ROT (*Sclerotinia*) was worse this year than previous years. The loss estimated for the State is 50 per cent.

PLUM, BLACK KNOT (*Plowrightia*) (see Fig. 23).—Specimens of this disease were received from Alamance county, where it was said to be of damaging importance.

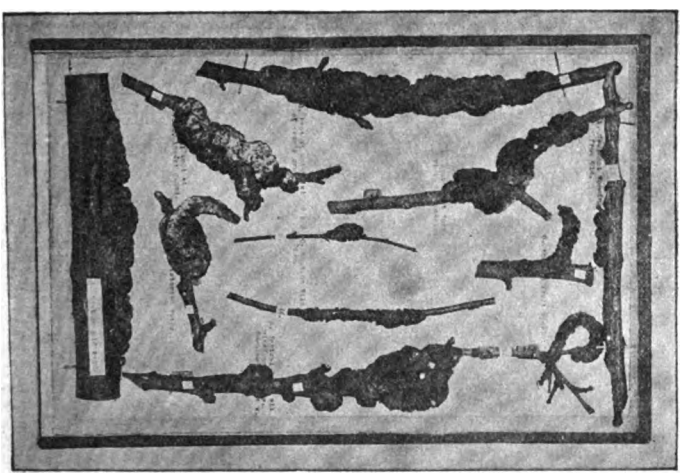

FIG. 23.—Plum Black Knot.

It is also very prevalent in the western mountain section. In Haywood county common saying reports it as the cause of the destruction of the plum and cherry industry in the lowland. Some of the worst specimens of this disease ever seen by the writer were collected in Macon county. It is to be fought by cutting and burning.

POTATO, EARLY BLIGHT (*Alternaria*) was seriously destructive in Randolph, Wake, Cumberland, Wayne, Lenoir, Duplin, Bladen and Columbus counties.

POTATO SCAB was said to be serious in the trucking region. Complaints in particular were received from Mount Olive.

QUINCE, BLIGHT (*Bacillus*).—This disease was seen in Transylvania county. It had previously been reported from Buncombe county.

QUINCE, RUST (*Gymnosporangium*).—This rust upon the fruit of the quince has been recorded from Rockingham, Rowan, Gaston, Buncombe, Transylvania and Cherokee counties. It was seen in Tran-

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sylvania County, and had been previously reported from many of the western counties of the State.

Rose, Powdery Mildew (*Sphærotheca*).—Complaints of this common mildew were received from Lincoln, Pitt, Duplin, Sampson and Edgecombe counties. It is easily controlled by spraying.

Rose, Black Spot (*Actinonema*) is abundant throughout the State on roses outdoors and under glass.

Salsify, Nematodes (see Fig. 24).—Specimens of very badly affected roots of this crop were received from Durham county, with a statement that portions of the soil were affected and other portions of the same row were free.

Strawberry Leaf Spot (*Sphærella*).—This disease was seen in Duplin, Pender, Columbus, Vance and Wake counties. It probably exists wherever strawberries are grown and is sometimes of very serious import. Valuable varieties have been protected by spraying. Some varieties are much more susceptible to the disease than others, and owing to the susceptibility of some of our best varieties, we are unfortunately prevented from growing them.

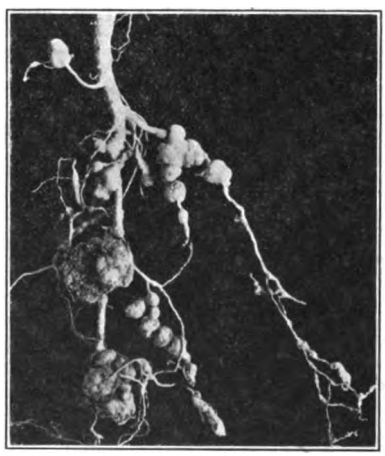

Fig. 24.—Salsify, vegetable oyster, root showing nematode galls.

Sweet Potato Leaf Spot (*Phyllosticta*) was very abundant in Wake county, and doubtless diminished the vigor of the vines somewhat, though to no very great extent.

Sweet Potato Wilt (*Fusarium*).—Reports from sections affected with this disease show less destructiveness than in previous years.

Sweet Potato Soft Rot (*Rhizopus*).—This fungus is the cause of most of the rotting of potatoes while in storage, and occurs extensively throughout the State.

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TOBACCO, THE GRANVILLE TOBACCO WILT.—Continues to spread and is reported as worse this year, and the loss is said to be 25 to 100 per cent of the crop in the affected region. The loss in one county is estimated this year at $20,000. It was estimated to be 40 per cent more destructive this year than last year.

TOMATO WILT (*Bacillus*).—In addition to counties previously reported it was noted this year in Vance, Wake and Bladen counties.

VETCH (*Ascochyta*).—Specimens of vetch from New Bern and also from Raleigh exhibited disease in the form of small spots upon leaves and stems. The spots were ashen or brown in the center, with a rather wide border of dark red. Each spot bore several pycnidia containing spores of the ascochyta type. It is evidently *Ascochyta Viciæ* Lib., which has been noted by Dr. G. P. Clinton, of the Connecticut Agricultural Experiment Station, as injurious in that State upon cultivated vetch.

VIOLETS.—The *Cercospora* of the violet ranks as one of the worst greenhouse diseases of the State.

WATERMELON WILT (*Fusarium*).—In addition to counties previously reported, it was heard from this year in Halifax, Robeson, Lenoir, Duplin and Pender counties.

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NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

B. W. KILGORE, Director.

PRESS BULLETIN No. 14.—DECEMBER, 1906.

A SERIOUS LETTUCE DISEASE.

Throughout the lettuce growing section, and particularly conspicuous in the neighborhoods of New Bern, Wilmington, Fayetteville and Maxton, occurs a disease of lettuce of extreme severity and destructiveness. It may be easily recognized by its symptoms.

The disease begins with the wilting of the outer lower leaves, which droop and fall flat upon the ground. A similar fate rapidly overtakes the inner leaves, and so on over the whole plant, till within a few days the entire plant is dead, lying flat upon the ground.

Upon the under side and at the base of the leaves will be noticed, at this time, dense cotton-like growths (Mycelium), and in the later stages small black, irregular bodies (Sclerotia), from a quarter of an inch to a half inch long and somewhat less in thickness will be found in similar situations. The sclerotia and mycelium are unmistakable signs of this disease.

This disease is known as the "drop," and has for several years been a serious menace to lettuce growing in many portions of the United States. It is caused by a fungus visible to the eye as the mycelium and sclerotia referred to above. If this fungus once gains entrance to the lettuce bed, no certain, or at least no economical treatment is known to get rid of it.

It is therefore extremely important that all growers who are now free of this disease take every precaution to keep free of it, also any growers who have a portion of their beds free should use every precaution to keep that portion from becoming infected.

These precautions consist in preventing any diseased plants or fragments of diseased plants or any of the mycelium or sclerotia from obtaining access to uninfected fields or beds. As soon as any plant shows an indication of this disease the plant should be pulled up, buried with lime, or destroyed by fire. The spot from which the plant was pulled should be thoroughly drenched with Bordeaux Mixture. If these precautions are followed, by those people who are not at all or only slightly affected with this disease, it will probably be possible to hold the disease in check.

F. L. STEVENS,
Biologist.

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PRESS BULLETIN No. 15.—OCTOBER, 1902.
Revised January, 1907.

Treatment of Oats, Wheat, Rye or Barley for Smut.

Very few farmers realize the full extent of the injury suffered by these cereal crops through the inroads of smut. The smutted plants are dwarfed, therefore escape observation so completely that even very observing farmers often allow as much as 25 to 35 per cent of smut to pass unnoticed. Smut is rarely less than 10 per cent in oats, and is frequently 16 to 25 per cent. This is a complete loss to the farmer, as it costs as much in seed, land and tillage to raise the smutted plant as to raise the full head. All of this loss can be turned into a clear profit at a cost of about one cent per acre for material and a very slight outlay of labor. The United States is suffering annually a preventable loss of about $18,000,000 from the smut of oats alone. Our own State is yearly losing between 10 to 20 per cent of her annual oat crop, ranging in value at about $991,516.00.

RATIONALE OF TREATMENT.

The smut of grain is caused by a fungus, the spore (the spore is the reproductive body of fungi, corresponding to the seed in higher plants), of which is carried in the seed to the young grain plant. Smutted plants in the field, and in threshing, shed their spores in the air. These spores are then carried about by the wind, many of them finding lodgment in the seed of neighboring plants. They are thus planted with the grain and the same moisture, warmth, etc., which starts the plant into renewed life quickens the smut. It thus happens that many young plants are, in earliest infancy, attacked by the smut enemy, which, having gained entrance, lurks within the plant until blooming time, when it again breaks forth in its well-recognized form. Only very young plants are susceptible to attack of the smut, therefore if we can so treat the seed of the plants as to destroy the adhering spores of the fungus without injuring the grain, we can enable the young plant to pass the critical stage of its existence in safety. It is thereafter safe. Such treatment is possible. Smut can therefore be practically eliminated from the field. Several kinds of treatment are effective, but of all those known that by formalin is by far the best and cheapest, although the familiar bluestone treatment is quite efficient in wheat.

TREATMENT.

Formalin can be purchased from a druggist at a cost of from 75 to 95 cents per pound. One pound mixed thoroughly with 45 to 50 gallons of water is sufficient to treat 45 to 50 bushels of grain.

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To treat the grain, spread it in a thin layer on a smooth barn floor and sprinkle with the diluted formalin, using either a spraying machine or a watering-pot. Sprinkle so as to thoroughly and evenly wet the grain with the mixture. Then shovel the grain over thoroughly a few times to insure even distribution and cover the pile with canvas, carpets, blankets, or bagging, to keep the fumes of the formalin within. The pile should stand from 6 to 12 hours in this way. The oats may then be readily dried by mixing with air-slaked lime, and the lime may be removed by the fanning-mill, or the lime may be omitted if desired. It is merely a drying agent. The seed is then ready to sow. It may be stored, but in so doing it is liable to renewed smut infection. The best way is to treat, dry, then sow as soon as is practicable.

In general, one gallon of mixture will suffice to treat one bushel of grain. The formalin should be used at the rate of one ounce to three gallons of water.

Formalin is an irritating caustic, which should not be brought into contact with the skin in pure form. In diluted condition it is harmless.

If you try this treatment simply as an experiment, sow the treated seed in a definitely marked portion of your field, using all care to keep the treated seed from smutted seed. If you are adopting this treatment for your whole sowing, it will be instructive if you will leave a small porotion, say one or two drill rows, with the same seed, untreated, thus enabling you to determine the real value of treatment.

We should be pleased to have you send a letter to the Station stating the results of your treatment, its cost, labor involved, amount of smut in treated and untreated fields. The amount of smut should be very carefully estimated in per cent from an actual count in the field.

F. L. Stevens,
Biologist.

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Bulletin No. 195 **June 1907**

NORTH CAROLINA

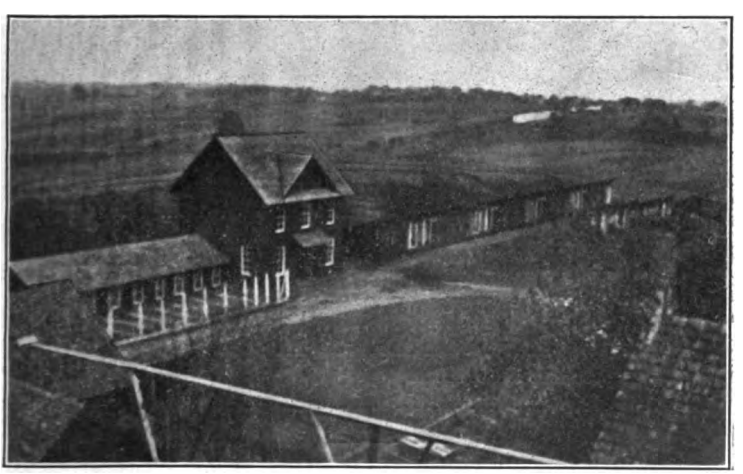
Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts

WEST RALEIGH

FARM POULTRY



PART OF POULTRY BUILDINGS AT EXPERIMENT STATION

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N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

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J. C. TEMPLE .....Assistant Chemist and Bacteriologist
A. F. BOWEN ....Bursar

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station.

Address all communications to

AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

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FARM POULTRY.

The Poultry Bulletins of the Station being exhausted, and there being a steady demand for information in regard to the housing, feeding and management of poultry, this Bulletin has been prepared to meet this demand. A report is also made of our work in pedigree breeding for egg production which was started last year, a test of the value of green feed and the comparative keeping quality of fertile and infertile eggs.

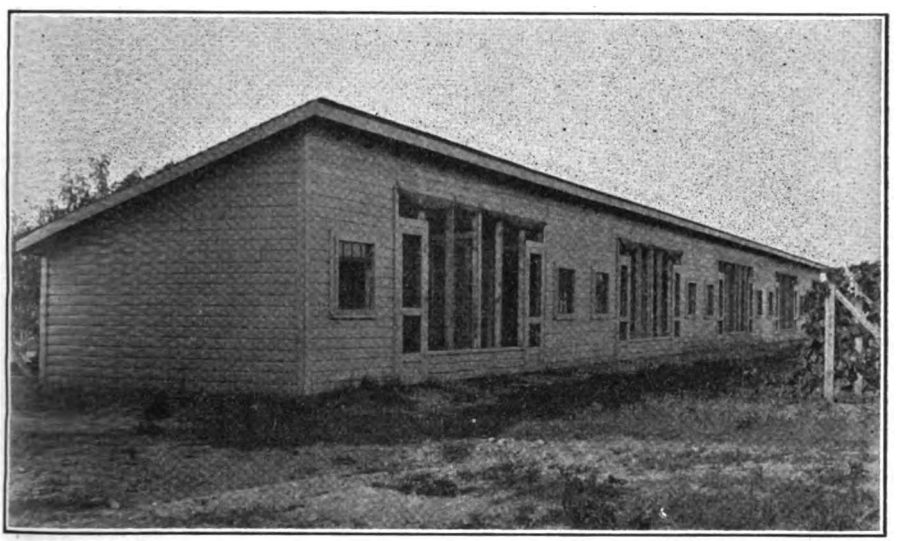

FIG. 1. Scratching Shed House with nine pens. (Photo by Hume.)

HOUSES AND YARDS.

The question of poultry house construction is not so important in our climate as it is in the North where the fowls are confined to the house for much longer periods than they are in the South.

There are, however, some points that must be observed no matter where the location may be, and in a warm climate some points need more attention than they do where it is colder.

In the first place, the house must be dry, and in order to have it dry it must not only have a rain-proof roof, but must be built on ground which has good drainage.

In order that the roof may be rain proof and that it may remain so for the longest possible time, give it a good slope, so that water

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will run off quickly and not have time to find any small leaks that may occur. It is quite a common thing to see poultry houses built with a roof that has a fall of only a foot or a foot and a half in ten feet, while a fall of four feet in this width would be much better, costing no more to build, and would last years longer than the flat one.

If a place which has natural drainage is not available for the house, it should be set up on posts or some other good foundation, so that it will be well above the ground and filled up with light, sandy soil, and the ground immediately around the house raised so as to turn the water from the house.

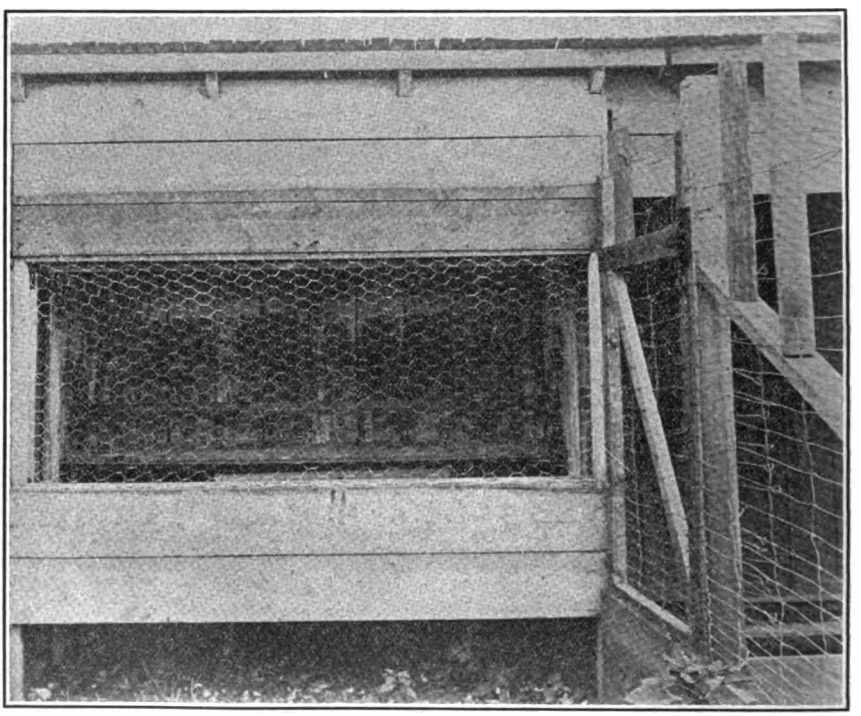

FIG. 2. Wire Front House with Scratching Room underneath. (Photo by Hume.)

Building should be done early enough in the season so that the house and ground will have plenty of time to thoroughly dry out before the fall rains begin or the house is apt to be damp the first winter in spite of all that you can do.

Figures 1 and 2 show two different types of the scratching shed house. In Fig. 1 the scratching shed and roosting rooms are side by side, a close board partition separating them.

In Fig. 2 the scratching room is underneath the house. Fig 1 shows the better arrangement, but is more expensive to build.

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Each flock has a house 10 x 18 feet divided into two compartments, giving a scratching room 10 x 10 feet and a roosting and laying room 10 x 8 feet. The cut shows a house of nine pens, but the house may be built with any number of pens desired.

The width of this house, 10 feet, is about right for most poultry houses, as it is not so deep that the sun can not shine to the back of it, and roosts at the back of the house are protected from wind and rain.

Figures 5 and 6 show the interior arrangement of the roosting and laying room, with the roosts hung on stop-lice hangers, a dropping board under them, and the nests under the dropping board.

Fig. 7 shows a corner of the scratching room, with grit and shell

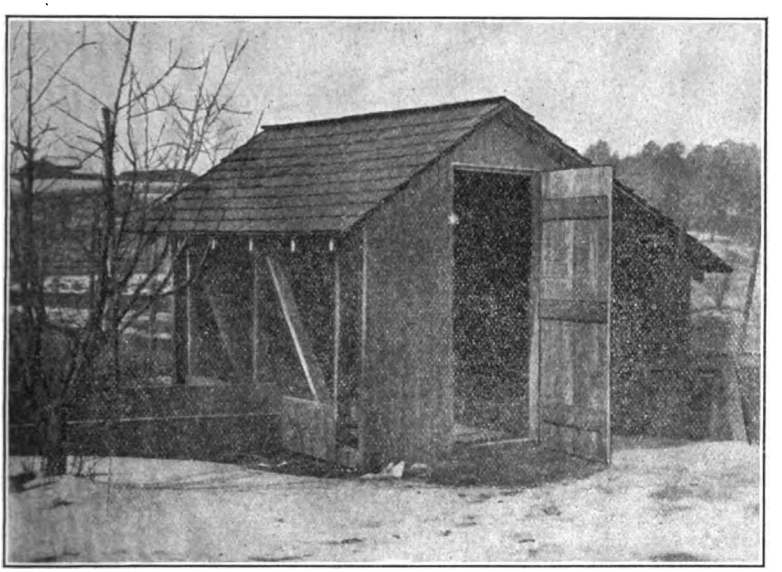

FIG. 3. Wire Front House with Long and Short Pitch Roof. (Photo by MacNider.)

box and dry food hopper in position. The scratching litter here is shredded corn stover.

The house shown in Fig. 2 is 6 x 8 feet, and with the roost only five feet from the open front, the fowls are sometimes wet on the roost by a driving rain. Other objections to the house are that it has a board floor and a scratching room into which the sun never shines.

A house 10 x 18 feet, as shown in Fig. 1, requires the following lumber to build: 360 feet ceiling or German siding, 250 feet roofing plank, 2 pieces 4 x 4 x 18 feet, 2 pieces 4 x 4 x 10 feet, 10 pieces 2 x 4 x 12 feet, 4 pieces 2 x 4 x 18 feet, 10 pieces 2 x 4 x 14 feet, and 1,500 shingles or prepared roofing.

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A house as shown in Fig. 2, 6 x 8 feet, requires the following: 300 feet plank 1 x 10, 60 feet flooring, 10 pieces 2 x 4 x 16, 10 pieces 1 x 3 for battens, and 500 shingles.

Figures 3 and 4 show two wire front houses, the former 10 x 10 feet for a single flock and the latter 10 x 20 feet, divided into two pens. These houses differ slightly in their construction, but are alike in their essential features. No. 3 is boarded with tongue and grooved ceiling, and has a long and short pitch roof, while No. 4 is boarded with 1 x 10 plank, and the cracks in the back and ends battened. The front of both is made of four-foot poultry wire and planking.

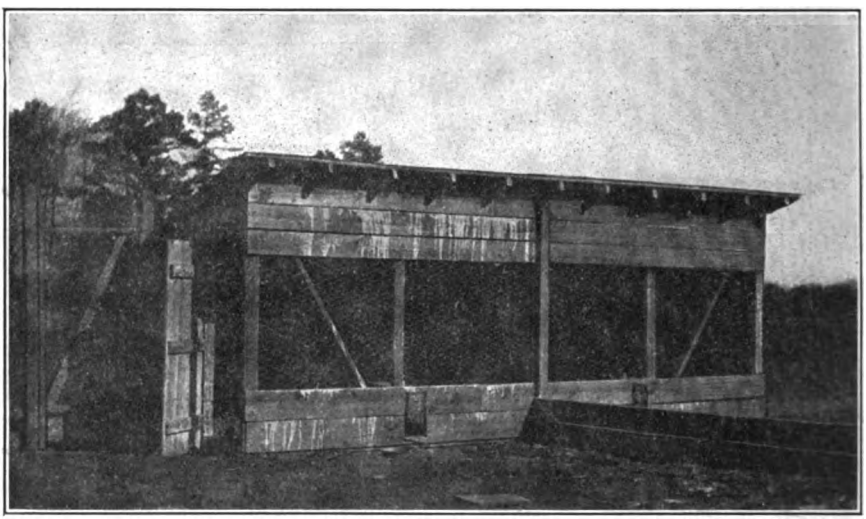

FIG. 4. Wire Front House with Shed Roof. (Photo by MacNider)

No. 4 has the advantage of being slightly cheaper, and is rather easier to build for a man who is not a carpenter. No 3 is built with 5-foot posts in front and 4-foot behind, and is eight feet to peak of roof. It requires the following bill of lumber: 225 feet ceiling, 170 feet roofing plank, 4 pieces 4 x 4 x 10 feet, 10 pieces 2 x 4 x 14 feet, 4 pieces 2 x 4 x 12 feet, 9 pieces 2 x 4 x 10 feet, and 1,000 shingles. No. 4 built 10 x 10, four feet high at back and eight feet in front, will take the following bill: 360 feet plank 1 x 10, 4 pieces 4 x 4 x 10 feet, 16 pieces 2 x 4 x 12 feet, 3 pieces 2 x 4 x 14 feet, 6 pieces 2 x 4 x 10 feet, 16 pieces 1 x 3 x 12 feet, and 900 shingles.

It will be noted that all the houses illustrated are built tight at the back and both ends and left more or less open at the front. The open front should always face the south or southeast. By this arrangement the fowls get plenty of fresh air and sunlight and still are not forced to roost where they are exposed to the wind and rain.

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No matter what the style of the house is it should be so arranged that everything can be easily cleared out of it, so that the walls can be thoroughly whitewashed or sprayed, and there will be no unnecessary cracks and corners for lice and mites to hide in.

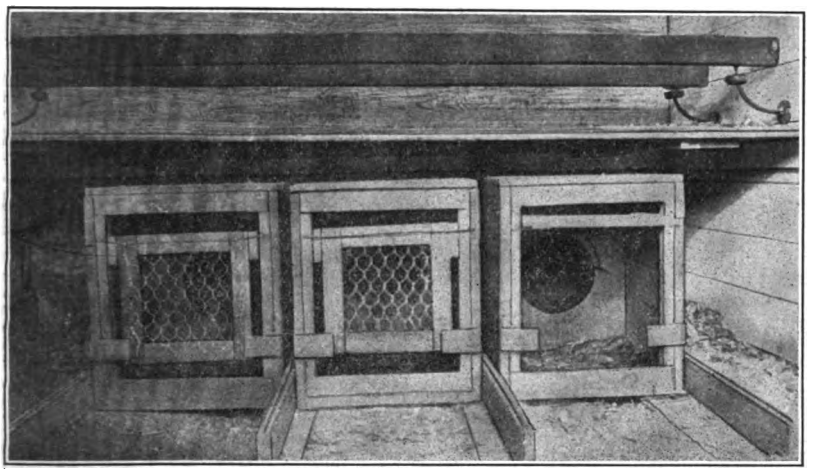

FIG. 5. Trap Nests. Two in use and the other set ready for the hen to enter. Also shows arrangement of roosts on stop-lice hangers and dropping board.

A convenient arrangement for the roosts and nests is shown in Fig. 5, and in all cases where the front of the house is open the roosts should be along the back wall as far away from the opening as possible. The dropping board should not be any higher than is necessary for the nests to go underneath it. If the ordinary nest is used 15 inches will be high enough, but if trap nests are used it will need to be 19 or 20 inches from the ground.

Ordinary nests are best made without any top or bottom, the dropping board forming the top and the ground the bottom. Have the nest open to the back of the house and leave room between the ends of the nest and the side walls of the house, so that the hens can pass around and enter the nest from the back. Have a strip along the back of the nest at the bottom to keep the partitions in place and to keep in place any nesting material used. The front of the nest should be hinged to facilitate gathering the eggs. If you have a good sand floor in the house no other material will be needed in the nests and you will thus do away with another hiding place for mites.

The roosts may be made from two by three-inch pieces set on edge and the top edges slightly rounded. They may be set on Stop-lice hangers, as shown in Fig. 5, or dropped into slots cut in boards attached to the dropping board, so that they will be about six inches above the board. In this latter case the dropping board should not

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be supported by the walls of the house, but should be set up on benches of the proper height and made so that it will not touch the wall at any place. In either case the roosts should be cut short enough so that they will not reach the walls at either end. This arrangement makes it difficult for the mites to pass from the walls to the roosts.

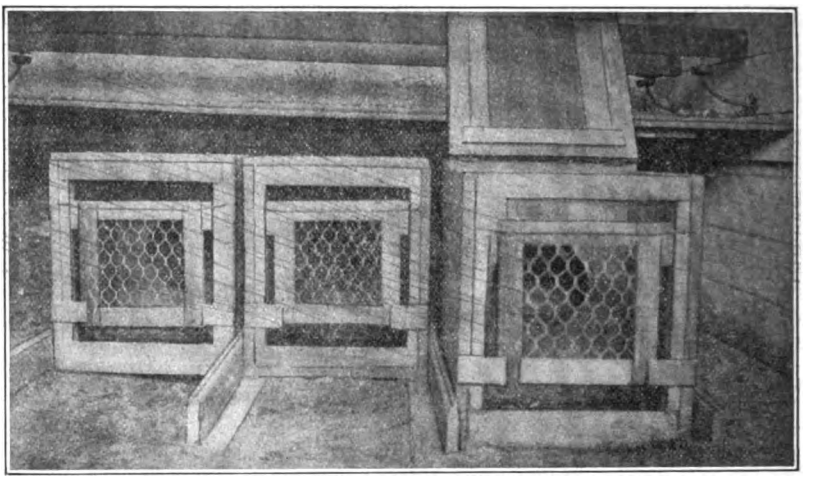

FIG. 6. Trap Nests, showing one drawn forward and top raised to remove hen after laying.

In estimating the capacity of the house it is well to be on the safe side and not overcrowd. This is especially true in regard to breeding stock from which you wish to hatch good, thrifty chickens. Any of the houses shown by Figs. 1, 3 and 4 are large enough for a pen of ten or twelve breeding birds, or if eggs for market only are wanted they will accommodate twenty-five hens.

It should always be remembered that the more crowded the fowls are the more precautions must be taken to keep good the sanitary conditions.

If the fowls are to be confined in yards most of the time, the yards should be large enough so that a green crop can be kept growing all the time. This can be better done where the yard is divided, as in this way the fowls can be kept off the crop till it has got a good start. If the fowls have farm range and a yard is only needed for the breeding stock while eggs are wanted for hatching, it need not be so large, as the crop can get a good start before the hens are put on it, and then will last for the time that the breeding is done. After the breeding season, the hens should be turned out with the rest of the flock, and the yard will make a good place to confine the male in till he is needed for breeding purposes again.

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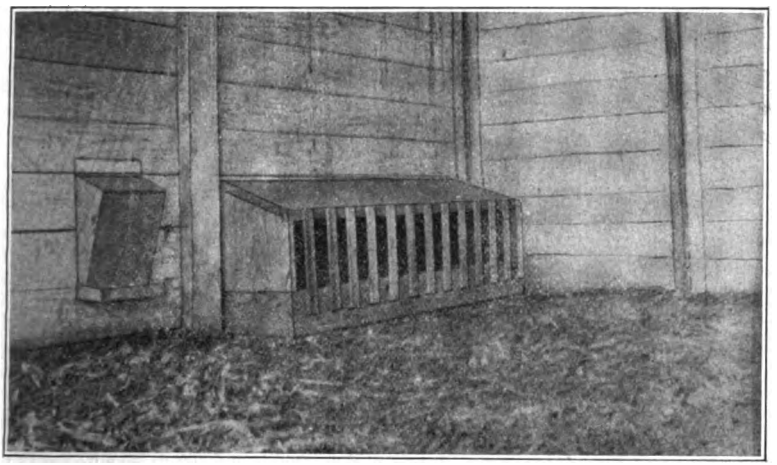

FIG, 7. A corner of the Scratching Shed, showing dry food hopper and grit and shell box.

BREEDS OF FOWLS.

It is not my intention to attempt to describe all the different breeds of fowls, as that would take more time and room than can be given to it in this Bulletin, so I will only give descriptions of the varieties kept at the Station. Anyone wanting a fuller description should procure a copy of the American Standard of Perfection, which gives ideal cuts and detailed descriptions of all standard varieties of fowls, ducks, geese and turkeys.

As previously stated, the cuts shown here are made from photographs of birds in our breeding pens, and in most cases give a good idea of the quality of the stock, but in a few cases do not do justice to the birds represented, as it is difficult to get a good photograph of a bird that is not coop trained and accustomed to handling.

PLYMOUTH ROCKS.

The Plymouth Rocks are the most popular of all the breeds for the farm. This is especially true of the barred variety, they being the oldest variety of this breed and the one most commonly seen on the farm. In fact, their popularity is so great in many sections that to say Plymouth Rocks means the barred variety. The good points which have made this variety so popular can be found in either the buff or white varieties, and from a market standpoint these lighter colored varieties have advantages over the darker barred variety. All varieties are fairly hardy, good winter and fair summer layers, and are good sitters and mothers. They lay brown-shelled eggs and have the yellow legs and skin, which most markets prefer.

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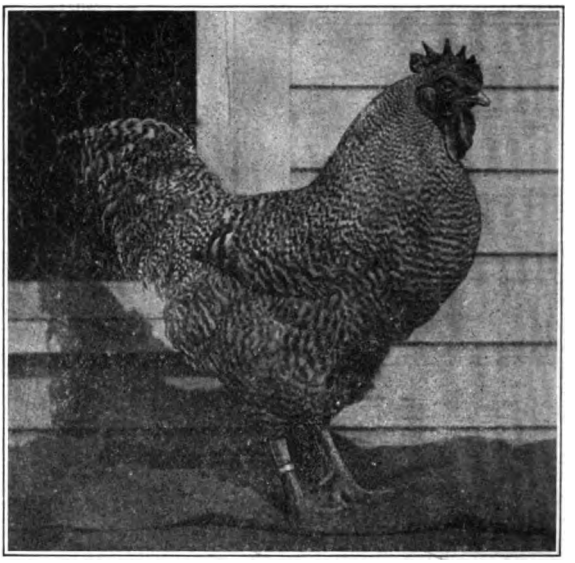

FIG. 8. A Barred Plymouth Rock Cock. A medium colored bird of good size and shape. (Photo by MacNider.)

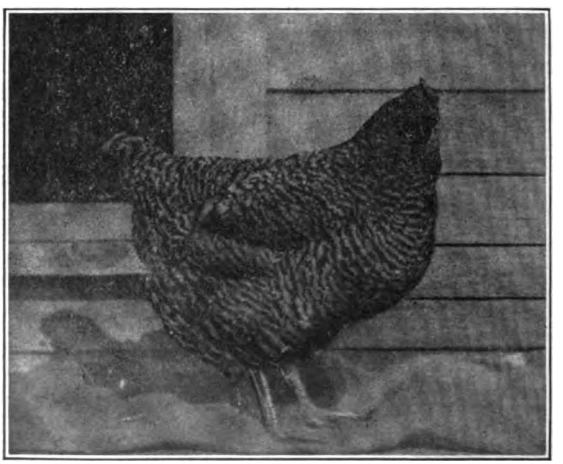

FIG. 9. A Barred Plymouth Rock Hen that has been a winner in some of the best shows in the country. (Photo by MacNider.)

Standard weights for all varieties are: Cock 9½ pounds, hen 7½ pounds, cockerel 8 pounds, pullet 6½ pounds.

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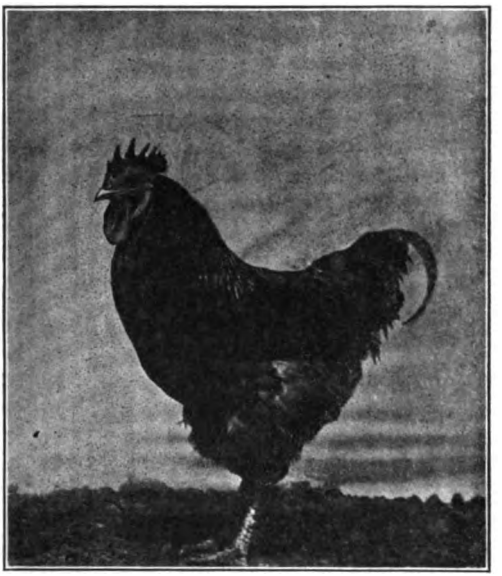

FIG. 10. A Buff Plymouth Rock Cock of excellent shape and color.

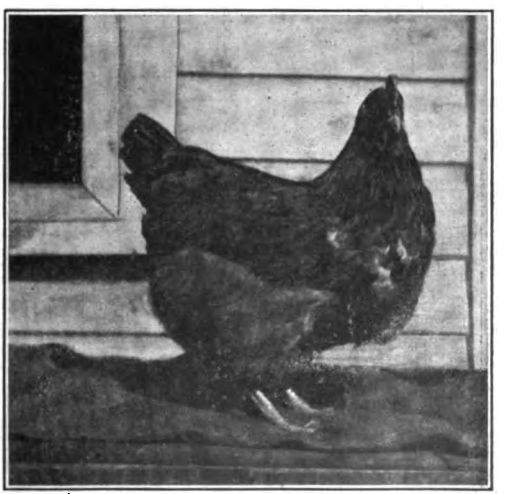

FIG. 11. A Buff Plymouth Rock Pullet, No. 6028. (Photo by MacNider)

WYANDOTTES.

In the Wyandottes we have more varieties and therefore a wider range of choice in the matter of color. The varieties we keep are the white and buff.

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The white, although not the oldest variety, are the most popular, and for the last few years have been one of the largest classes at Fairs and Poultry Shows.

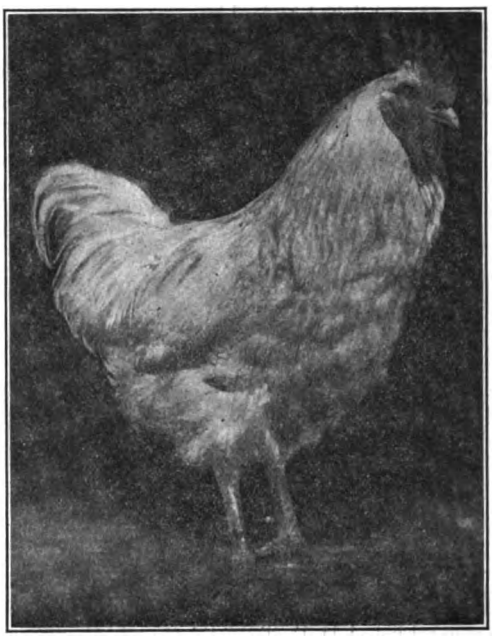

FIG. 12. A White Plymouth Rock Cockerel. (Sold to N C. Department of Agriculture for their Edgecombe County Test Farm.) (Photo by MacNider.)

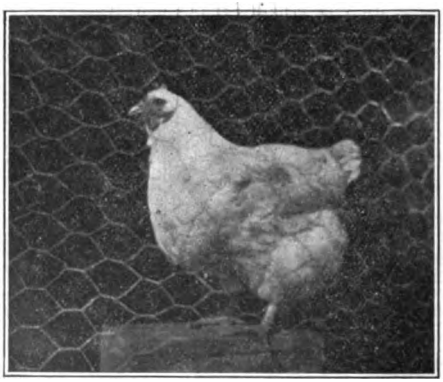

FIG. 13. A White Plymouth Rock Hen of good shape and absolutely white.

The Wyandottes have the same general characteristics as the Plymouth Rocks, but are smaller and more blocky. They are quick maturing and make first-class broilers or medium-sized roasters. All

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varieties have the rose comb. They are good winter and fair summer layers, are good setters and mothers, lay brown-shelled eggs and have yellow skin and legs.

Standard weights are: Cock 8½ pounds, hen 6½ pounds, cockerel 7½ pounds, pullet 5½ pounds.

FIG. 14. A very typical White Wyandotte Cock of good color. (Photo by MacNider.)

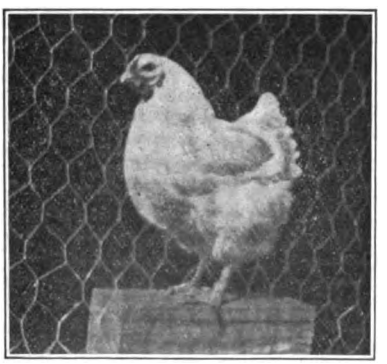

FIG. 15. White Wyandotte Pullet. Note the neat head, full breast, short slightly cushioned back and well spread tail.

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FIG. 16. A Buff Wyandotte Cockerel of good style

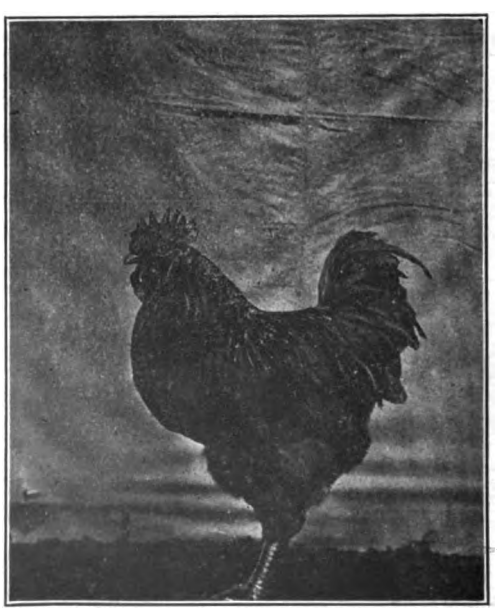

FIG. 17. A Buff Orpington Cockerel of sound color and good shape.

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ORPINGTONS.

There are several varieties of this breed, but the Single Comb Buff are by all odds the most popular and the most commonly kept, and are the only variety that we keep.

They are a comparatively new breed, of English origin and were first brought to this country in 1898 and were admitted to the Standard in 1902. They are the largest of what may be called the general purpose breeds. They are fairly hardy, good winter and fair summer layers, are good setters and mothers and lay brown-shelled eggs, but have white flesh and legs. The chicks grow and feather rapidly and make good broilers and roasters.

Standard weights are: Cock 10 pounds, hen 8 pounds, cockerel 8½ pounds, pullet 7 pounds.

LEGHORNS.

This breed has also a number of varieties, but those most commonly seen are the Single Comb White and Brown.

The Leghorns are classed as one of the egg breeds and are, as a rule, prolific layers, especially in warm weather. My experience has been that they do not do as well as some of the heavier breeds, such as the Plymouth Rocks and Wyandottes, during the winter, and are more susceptible to weather changes, a cold snap checking egg production much more in them than in the heavier fowls.

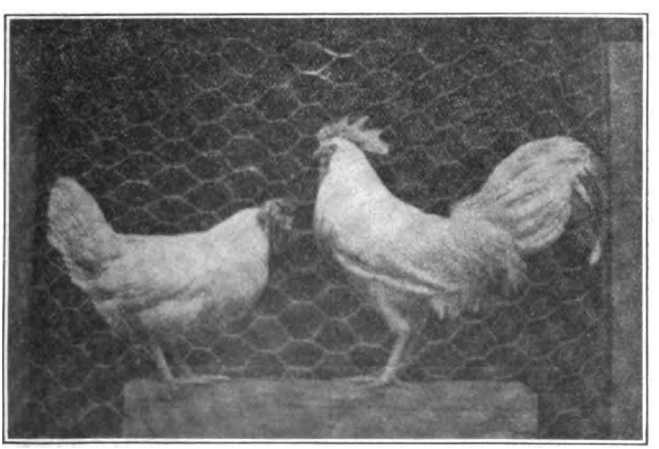

FIG. 18. White Leghorn Cock and Hen. Birds of good shape and color and the hen a good layer of extra large eggs.

The white, as a rule, lay larger eggs than the browns, due, no doubt, to their having been more carefully selected and bred for this point, as they are largely used to supply the New York market, which pays a premium for large, white-shelled eggs.

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There is no standard weight for the Leghorns, but size is of importance and is recognized in the Standard, eight points being allowed for this point. A large strain of Leghorns make good broilers as well as good layers, if the demand is not for a very large broiler, as they feather quickly and for the first three months make rapid growth.

MINORCA.

The Minorca is the largest of the egg breeds and the only one that has a standard weight. They are good layers of extra large eggs, and where a premium can be had for extra large eggs will make a good fowl to keep, but my experience has been that they are not as economical producers as the Leghorn.

Standard weights for the Single Comb Black are: Cock 9 pounds, hen 7½ pounds, cockerel 7½ pounds, pullet 6½ pounds.

LIGHT BRAHMA.

This is the largest breed of poultry, and where large roasters or capons are wanted they will answer well, but on account of their large size and slow maturing they are not well adapted to the produc-

FIG. 19. A Fine Light Brahma Cockerel and Pullet.

tion of broilers and small roasters. On account of their feathered legs they are not well liked by many for our warm climate.

They are fairly hardy, fair winter layers and only fair as sitters and mothers as, on account of their large size, they are often clumsy and are apt to break the eggs and crush the chicks.

Standard weights are: Cock 12 pounds, hen 9½ pounds, cockerel 10 pounds, pullet 8 pounds.

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PEKIN DUCKS.

The Pekin may justly be called the market duck of America, as they are used for this purpose almost exclusively on the large duck ranches. They are hardy, fair layers and mature quickly. As a

FIG. 20. Pekin Ducks five weeks old. (Photo by Hume.)

rule, they do not become broody and hens or incubators must be used to hatch the young.

When raised for market they should be forced from the start and marketed as soon as fully feathered, which is usually at about ten weeks old. If kept longer the profit is not so large, as they moult soon after this time, and most of the food goes to the production of feathers instead of meat.

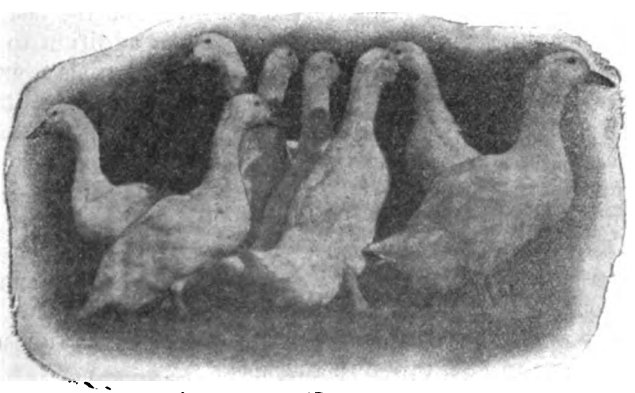

FIG. 21. The same Ducks three weeks later.

It is an advantage to have water for the breeding stock, as the eggs are usually more fertile under these conditions, but it is not absolutely necessary, as fair success can be had without water except a plentiful supply for drinking purposes. The young ducks will grow faster and fatten better if kept away from the water.

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SELECTING THE BREEDING STOCK.

Many think that if they are going to do anything with poultry they must have several different varieties. For the farm they could hardly make a more serious mistake. In the first place, where more than one variety is kept, the fowls must be confined or they will cross, and you will soon have no pure bred stock. If you have to confine your fowls you lose one of the greatest advantages that the farmer has in keeping fowls, as when they have free range they will find a large proportion of their food which would otherwise go to waste.

Secondly, if you have several varieties, you lose that uniformity of your product which is desirable either in your poultry or eggs.

Perhaps the most common mistake made by farmers in their breeding of poultry is that they breed from all the hens in the flock without any pretense of selection. Our progressive farmers are all wide awake to the necessity of seed selection if they want to get the best returns from their field crops but few have thought it necessary to carry this matter of selection to their poultry where it will give just as good returns as in any other crop raised on the farm.

In selecting breeding stock the first consideration should be given to constitution and vigor. Without this neither male or female will ever be a success in any branch of poultry work. A cock who is always on the move, calling the hens and scratching for them, whose crow is the loudest, the first to be heard in the morning and the last at night, is not apt to be lacking in this respect. If in addition to this you have a bird that is well set up on good stout legs placed well apart, with a full well-rounded breast, a broad back with the width carried well back to the tail, a stout neck, not too long, and a broad head and full, bright eye, you have one that is all right to head your pen, no matter what his breed may be.

The females should have the same general characteristics.

Watch the hustlers. The hen first down from the roost in the morning and last up at night, always on the hunt for something to eat, is the one that is likely to give you the eggs. The one that gets off the roost when you come to feed and sits around after being fed is more than apt to be a drone in the flock.

Select as many of your best hens as you think will be needed to raise as many chicks as you want and mate them with a cock such as described, giving them a small house and yard to themselves for the breeding season and you should make good progress in the improvement of your flock.

If you need more hens than one male can attend to, have two males and run them with the hens on alternate days to avoid fighting. It is always better to have too few rather than too many hens with the male. I have found on several occasions that I could reduce the

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number of hens in the pen and increase the number of chicks from the pen.

Fowls in their second year are generally the best for breeders, and you then have the advantage of being able to select those that have been the best performers in their first year. There would be no objection to occasionally using a well developed pullet in the pen if she had some point of excellence in a marked degree and if you mate her with a cock, but the practice of continually breeding from pullets and cockerels will almost, without exception, end in a deterioration of the flock.

FEEDS AND FEEDING.

In most places in the South the condition of high-priced feeds has to be faced, and it is not likely there will be any change in this condition as long as we have to depend on the Northern and Western States for a large proportion of our supply.

Let us divide the feeds into three classes, viz, Grains and their products, Green feeds and Animal feeds.

For grain food we have to depend almost exclusively on the following: Corn, wheat (mostly screenings), and oats.

We feed considerably more corn than all the other grains put together, because it is the cheapest feed that we can get and we can get it at all times, which we can not say of the other grains, at least at a price that would admit of their being fed to poultry. All our corn is fed either as cracked corn or corn meal. We feed no whole corn at all. Corn is a carbonaceous food, supplying heat and fat-producing materials in excess of the wants of fowls under most conditions, but by combining it with green and animal food we are able to use it quite largely and make it the base of our ration. On account of the large size of whole corn the fowls can get a feed of it with practically no work, and it is to get over this condition that we crack it. Fed in this way in litter where the fowls have to scratch for all they get, it can be more liberally fed without the fowls becoming over fat from it.

Wheat is generally conceded to be the best one grain for poultry. It contains food elements in very nearly the proportions that fowls need them. In this neighborhood it is not often that good wheat can be bought at a price that will allow of its being used for poultry feed. Good wheat screenings, when they can be got, are almost as good as milling wheat for poultry feed, but this will not apply to samples that are largely made up of chaff and weed seeds. It is more important to buy screenings by weight than sound grain, as it will not weigh as much to the measured bushel, and if bought by the measure one often pays as much for it as for good milling wheat.

Oats of good quality contain about the same food value as wheat, but on account of the coarse husk are not as well liked as wheat or

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corn. Fed either ground, or soaked in water for some hours, they are eaten better. They are specially good for feeding to growing breeding stock.

Corn meal, wheat bran and ground oats are used in making our mash. It is important that the fowls have an abundant supply of green food at all times if they are to do their best. I have often thought that the Southern farmers and poultrymen are not making the most of the advantage they have in a mild winter by having a growing crop of some kind for their fowls to run on. The value of the green food comes quite as much from the action it has on the digestive system, toning it up and keeping the fowl in good health, as from its actual food value. It seems to be specially necessary and beneficial where we depend largely on corn in our ration.

We have used several crops for winter green food, some of the best being rye, rape and salad turnip.

Rye is, I believe, the best all round crop for this purpose, as it is quick growing and stands pasturing by the fowls well, and if not pastured too heavily will last from October till the middle of May, giving good grazing all through the winter in our average winter.

Rape and turnip make good grazing for a while, but my experience has been that they do not last as well as the rye, and they are harder to grow, requiring better land and a better preparation than for rye.

Clover makes a fine crop for this use, but is not so certain of making a stand as the other crops mentioned.

In sections where cabbage is grown the heads that are not marketable can often be had for the hauling or at a merely nominal cost and make a good winter feed.

THE EFFECT OF GREEN FOOD ON THE FOWLS.

In order to test the effect of green food on fowls enough hens to eat out completely all the rye in one pen were put in during the fall. Then two lots of Barred Plymouth Rocks, as nearly alike in age and condition as possible, were mated. One lot was put in the pen from which the rye had been removed and the other in a similar pen alongside of the first and which had a good stand of rye in it. The housing and feeding of both pens were the same except in the matter of the green food.

Below you will find recorded the number of eggs laid by each pen for the months of February, March and April:

	With Rye.	*Without Rye.*
February	71	65
March	86	82
April	83	30
	240	177

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This shows an increase of 63 eggs in favor of the fowls having the green feed. The feed of both pens was a mash composed of equal parts of corn meal and wheat bran with 10 per cent of beef scrap added; for grain they had cracked corn and wheat screenings in the proportion of two parts of corn to one of wheat. Early in April our supply of wheat screenings was exhausted and, being unable to get any more, both pens had no grain except cracked corn. Before the end of April the fowls without rye went badly out of condition and three of them died from indigestion and liver trouble. The balance of the flock were turned out on grass and have come round all right. These were the only cases that we had of indigestion this spring, although all our fowls were fed the same food with the addition of green food of some kind.

I think this case indicates very clearly the value of green food, especially when used in conjunction with a ration made up largely of corn.

ANIMAL FOOD.

Animal food may be supplied in several different forms; the most common probably being some of the commercial feeds put out by the packing houses, such as beef scrap, meat meal, blood meal and digested tankage.

The advantage of these feeds is that they will keep well in almost any climate as long as they are kept dry, and are ready for use at any time. The only objection to them is their cost, which is higher than green cut bone.

Green cut bone, if obtainable, is probably the best source of animal food as well as the cheapest. The objections to it are the difficulty in getting a regular supply of perfectly fresh bones and the work in preparing it for the fowls. In many places bones can be got from the butcher for one-half cent per pound, and at that price are cheaper than commercial feeds; but it is necessary to have the bone fed to the fowls while fresh, and this in summer means that the bone must be fed the day that it is cut. If allowed to become tainted it is dangerous to the fowls and had better be thrown away than fed in that condition.

Skim milk is a source of animal food that is often overlooked in poultry feeding, and where it is available is often used for other stock when it could to better advantage be used for the hens and growing chickens. Our own experience as well as that of others has been that milk is a very valuable addition to the ration for laying hens, especially in summer.

The general practice among poultrymen is to feed part of the ration in the shape of grain, either cracked or whole, and part as a mash. The advantage of the mash is that by mixing the feeds the hen is obliged to eat them in the proportions in which they are sup-

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plied and the ration can in that way be balanced to the needs of the hen for egg production or for whatever you are feeding and not to suit her individual taste. The question to-day is not whether to feed a mash or not, but how to feed the mash.

Until recently the common practice has been to mix the mash with water or milk and feed in a wet, crumbly condition in pans or in a trough.

The difficulty with this method has been that some of the hens would gorge themselves with this wet mash, which they could gulp down quickly, and if the quantity was not ample for all some would get too much and some not enough, the former suffering in time from indigestion and the latter never getting enough to allow them to make a satisfactory egg yield.

Recently some have been advocating the feeding of the mash dry, claiming that it was a more natural method and that the fowls fed this way were not so liable to digestive troubles, as on account of the mash being dry it could not be swallowed as readily as the wet mash could, and that the hens took longer in feeding, and that the food was better mixed with the digestive juices and not so liable to sour in the crop and cause trouble. From this beginning some have developed a system of feeding in which they feed only once a week, using hoppers to hold the feed, so that it will always be before the fowls and at the same time being so constructed that the fowls can not get into them and waste the feed. Some use the hoppers for the mash only, still feeding the grain in litter at stated times, and others feeding the entire ration from the hoppers, allowing the hens access to the food at all times. This latter seems to give good results for fowls on range and for growing stock also on range, and it can be seen at a glance that by this system the expense of the labor for feeding is cut to a minimum. Whether it would be as satisfactory or not for fowls in confinement I am not prepared to say, as I have not tried it; but for the last four months most of our breeding stock have had the mash part of their ration dry in hoppers before them at all times and while we have not tried the system long enough to say positively that it is better than the wet mash method, as far as we have gone it has been a success and it is certainly a considerable saving in labor to feed even the mash in this way.

Fig. 7. shows the feeding box that we use in the breeding pens. This is made with the top hinged so that it can be raised to put the feed in. It has two compartments, one three feet long and the other one foot long, the former for the mash and the latter for beef scrap. Our breeding stock gets a feed of grain in litter the first thing in the morning and can help themselves to the dry mash at any time that they care to. There is no crowding at the feed box the way there was at the trough when the mash was fed wet and all given at one time

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during the day. The hens will take a few mouthfulls of mash and then go for a drink or to look for a stray grain of wheat or corn, and then back to the feed box again till they are satisfied. In this way a much larger part of their time is taken up with their feeding and they have less time to get into bad habits, such as feather pulling and egg eating.

The feed box shown is only open at one side and is intended for use in the house only, but by having the slats on both sides and the cover made sloping from the middle to both sides and extending far enough over the sides to protect the contents from rain it would answer well for outside use for growing stock.

EGG PRODUCTION.

When we come to the matter of egg production and the selection of breeding stock for that purpose, the suggestions made previously are all right as far as they go, but for this work we must go further and consider the performance of each individual hen. This can only be done by the use of trap nests.

This work was first started in February, 1906, and while we did not find any extraordinary layers among our stock, we found some good ones, and also some that certainly were not earning their board. After keeping the records for two months we cut out all the Barred Plymouth Rocks but four, keeping the same number of the white variety and only one of the buff.

Shortly after making the selection we were unfortunate enough to loose one of the barred hens that gave promise of being the best layer in the lot (No. 5118), and this without getting any chicks from her, as all her eggs that were incubated were infertile. Later in the season we lost, by an accident, the next best one of the four (No. 5113), but in this case we secured three pullets from her. These pullets were June hatched and did not develop early enough to begin laying till the end of February. Only one of the three (No. 6076) has so far shown any signs of having inherited her mother's laying qualities.

Records were kept last year for only four months, from the first of February till the end of May. This year we will keep the records for the entire year.

Below are given last year's records of the hens mentioned as being reserved for this year's work. In addition to these we had the best of the pullets raised last spring.

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FIG. 22. Barred Rock Hen No. 5110 (cockerel bred). One of our best layers.

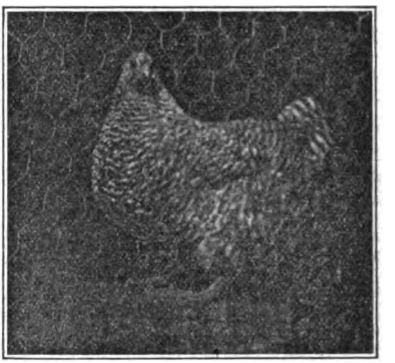

FIG. 23 Barred Rock Pullet No. 6076. A daughter of No 5113, and a promising layer.

				Feb.	*March.*	*April.*	*May.*	*Total.*
Barred	Rock,	No.	5110....	19	13	11	11	54
"	"	"	5111....	3	21	11	12	47
"	"	"	5113....	9	18	20	16	63
"	"	"	5118....	17	26	3*		46
White	"	"	70....	17	19	11	12	59
"	"	"	5135....	19	19	15	15	68
"	"	"	5137....	10	14	13		37
"	"	"	5138....	14	18		13	45
Buff	"	"	5128....	3	17	13		33

*Became broody after laying 46 eggs in 54 days; was broken up, but died on the 9th April.

Below are given the records for the first four months of this year. It will be noticed that out of the five hens now in the pens that were in last year's records, four have made better records this year than they did last. This it is thought is due to the change in the manner of feeding noted above. As the Buff Rocks were not mated up till January 21st, their records are only given for three months. The four pullets, Nos. 6162, 5052, 6028 and 6163, are all daughters of No. 5128. No. 5128 and 6162 both became broody early in April and did not begin to lay till after May first. No. 6028 died March 16th. As has been previously stated, No. 6076 was late hatched and did not start to lay till the end of February, so her record for March and April only are given.

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				Jan.	*Feb.*	*March.*	*April.*	*Total.*
Barred	Rock,	No.	5110....	16	8	23	11	58
"	"	"	5111....	18	16	16	12	62
"	"	"	6076....			24	18	42
Buff	"	"	5128....		14	20	5	39
"	"	"	6028....		19	10		29
"	"	"	6162....		20	18	4	42
"	"	"	5052....		17	23	18	58
"	"	"	5163....		14	23	19	56
White	"	"	70....	12	9	14	15	50
"	"	"	5137....	19	17	11		47
"	"	"	6145....	2	18	19	18	57

The trap nests (Figs. 5 and 6) used are of the same design as those used at the Maine Agricultural Experiment Station. Fig. 5 shows two of the nests occupied by hens and the other set ready for the hen to enter. Fig. 6 shows the third nest drawn forward and the top raised to remove the hen after she has laid.

We have found this style of nest very satisfactory and have had little trouble in getting the hens to use them. Occasionally, however, we have a pullet that refuses to lay in them, but by closing up the space shown at the ends of the nests, so that the hens can not get behind or in the corners to hide their nests, we have little trouble in this way.

COMPARATIVE KEEPING QUALITY OF FERTILE AND INFERTILE EGGS.

The farmers of the South suffer a heavy loss every summer on the eggs that they sell on account of the poor condition in which these often reach the market. It is such a natural condition that in warm weather any product of this nature should deteriorate quicker than it does in cool weather that many people have accepted the loss as unavoidable and made no effort to remove the cause of it.

The fact that an infertile egg will stand a temperature of 103 degrees for ten days and still be fit for use as food, although of course not equal in quality to a new laid egg, should point us to a remedy for a large part of the trouble with eggs not keeping in hot weather.

A fertilized egg is a living organism, and all that is necessary to start the growth of the germ cell is heat, and while 103 degrees is the best temperature for incubating the egg, it is well known that the germ will begin to develop at 90 degrees if this heat is continued for a few hours. It is no uncommon thing for the temperature to run this high for days at a time in summer, and unless care is taken to keep the eggs in a cool place, such as a cellar, they are sure to be injured. Even if they are so kept and leave the shipper in good condition, they are often ruined in shipment, as a short time on a railway platform in the sun will do the mischief. Then when night

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comes the temperature drops and the germ dies, and where death occurs putrefaction always follows.

From this it will be seen that the fertilization of the egg is largely responsible for the loss of eggs in warm weather. Therefore, if we can prevent eggs from being fertilized we have removed the principal cause of the trouble, and as this can be done by simply removing the males from the flock, there is no reason why any one should put up with loss from this cause.

In order to ascertain just what the difference would be between the fertile and infertile eggs, when we were done hatching last season we left the males in three of the pens, removing them from all the rest. After ten days we put up all the eggs from the pens in which the males had been left and at the same time put up an equal number from the pens from which the males had been removed. These eggs we intended to keep in a room upstairs where they would be under the average conditions under which eggs would be kept throughout the country. Rats destroyed some of them, and we were obliged to put them in the incubator cellar, which was comparatively cool and the conditions were decidedly favorable to the fertile eggs. The eggs were gathered for two weeks and all then stood for a week, after which all were broken and examined.

Of those from the pens where the males were, 15 per cent were bad and the quality of the balance was not as good as that of the infertile lot. In the infertile eggs there were none bad, and while some were slightly shrunken the general quality was good.

INCUBATION.

The hen is still the most commonly used incubator on most North Carolina farms, but there is no doubt that artificial incubation is in much more general use now than it was a few years ago. Our rapidly increasing population, with more money at their disposal, has created a demand for poultry and eggs greatly in excess of the supply, and there has been, as a result, a marked increase in the price of these products. As the price has advanced farmers have been more anxious to supply the demand, and a great many have looked to the incubator to help increase their stock of chickens.

Where one wants only a few chickens and there is no special demand for them early in the season, the plan of hatching by hens will answer very well. There has been no incubator manufactured to date that will do better work than a good, reliable, broody hen, but, unfortunately, all hens do not make reliable setters.

In keeping track of the eggs put under hens and those in my incubators, I have on different occasions, when I had a number of hens set, found practically no difference in the percentage of chicks hatched by the two methods. I have always had some hens that

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would hatch a larger percentage than I have ever been able to get from the incubator, but, on the other hand, I always have some eggs broken by the hens, and occasionally a hen will leave the nest and ruin the whole of the eggs given to her.

Whether it will pay to use an incubator depends not only on the market that is available, but to a certain extent on the person who is to look after the machine or the hens. A person who has a natural liking for working with the hens and has no mechanical turn is apt to do better work with the hens. There are several makes of incubators now on the market that any person of average intelligence can operate successfully, even from the first, if he will follow carefully the instructions sent with the machine.

A great many are disappointed with the results that they get with their incubators, because they expect too much. Having read of 95 per cent to 100 per cent hatches, they expect to get them from the start, while experienced poultrymen are well satisfied if their hatches run from 75 per cent to 85 per cent of the fertile eggs. Why the balance of the eggs which are fertile and often have well grown chicks in them do not hatch is a disputed point, some claiming that the trouble is in the machine and others that it is in the eggs or the stock that produced the eggs. I expect that both are sometimes to blame. The introduction of trap nests has shown me in two seasons work that I have some hens whose eggs will almost every one give a live chick, either in the machine or under a hen. There are some that will hatch well under a hen but not so well in a machine, and others whose eggs will not hatch by either method. All these hens were fed and cared for in the same manner and, in some cases, the two extremes come from hens in the same breeding pen.

The most striking example that we had last year of the eggs hatching well in both tests was the Buff Rock hen, No. 5128. Almost every egg from this hen that was incubated gave a chick, and the chicks were unusually strong and vigorous. It was on account of this quality that this hen was selected from all the Buff Rocks of last year to be used this year as a breeder. A reference to the remarks on pedigree breeding for egg production will show what the hen and her daughters have done as egg producers. When I add that a son of hers went through five of the best shows in the South last fall and winter and came out with five blue ribbons to his credit, and that her daughters divided four of the five firsts at these shows between them, it will be seen that her selection has been amply justified. I mention the matter of the shows because it requires birds of stamina and vigor to make show birds of the best quality and to stand the strain of showing for any length of time.

On the other hand, the Barred Rock hen, No. 5118, never gave us any eggs that would hatch. These two cases show that there is as

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much difference between hens in the matter of laying eggs that will hatch, as there is in the number of eggs that they will lay in a season. Much can be done by careful selection of the breeding stock to avoid the very annoying experience of finding a large number of chicks dead in the shells when the hatch is over.

The thorough disinfecting of the incubator before each hatch will also, I believe, give some relief from this trouble. One bad egg in a lot will contaminate those near it, and it is quite a common condition to find at the end of the hatch some eggs in which the chicks have died and putrefaction has set in. The germs from these eggs remain in the incubator and attack the fresh eggs put in for the next hatch, weakening the vitality of the chick, in many cases so that it dies in the shell, and those that do hatch start life with a handicap from which they never fully recover. The fact that new machines often give better results the first hatch than can ever be got from them again, and that the first hatch at the beginning of the season often gives stronger chicks than can be got later in the season, even with a higher percentage of fertility, seems to indicate that the sanitary conditions in the machine are not as good after a few hatches have been run as they were at first. For this disinfection I would recommend one of the coal tar products such as Creolin Zeuoleum or Chloro-Naptholeum, using a five per cent solution.

One great advantage of the machine is that it is always ready to use. What is more annoying than to have plenty of eggs from the hens that you want to hatch from and not a broody hen to hatch them? A greater number of eggs can also be hatched with the same work in incubators than with hens, and the chicks have the advantage of being hatched free of lice, which is an important consideration in our warm climate. Again, where the incubator is used, the hen can be kept at work producing eggs instead of hatching them. It is not often difficult to break up a broody hen, especially early in the season, if she is taken from the nest as soon as she becomes broody and put in a strange pen where there is no nest. I have frequently had a hen back in the breeding pen and laying in a week's time. But the sooner they are moved after they take to the nest the easier it is to break them.

If this plan is followed for a few years it will be found that the hens will become less and less addicted to the habit of setting and will be easier broken from it when they become broody.

When hens are used for hatching they should always be moved from the hen house and put where other hens can not bother them. There is little danger of breaking up the hen if she is moved carefully after dark. I prefer to make the nest on the ground, using the skeleton nest referred to previously, laying a plank on top and throwing a sack over the front for a day or two till the hen becomes accustomed

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to the new quarters, when both sack and plank may be removed. Hollow the earth slightly and make the nest with soft hay or straw.

The hen should have a good dusting with insect powder two or three times during the hatch, the last time just before the eggs are due to hatch. If the hen has to be covered up at the first it is better to delay the first dusting till the cover is removed, as some of the lice powders now on the market are so strong that they will injure the hen if freely used on the hen when closed up in a small space. If a number of hens are set in the same place it is best to remove them once a day for feeding and see that they get back on the nests again, otherwise two may take to the same nest and let a lot of eggs get chilled.

Many people do not use an incubator because they think that they have no place suitable in which to run it, thinking that in order to get good results a special incubator house is necessary. The fact is, that incubators are successfully operated in about as many different kinds of places as those in which hens are kept. If several machines are used it will be better to have places that are not used for any other purpose. The best conditions for artificial incubation are a fairly even temperature, good ventilation without drafts, sufficient light, without the direct sunlight striking the machine, and a fair supply of moisture. A cellar usually supplies the even temperature and

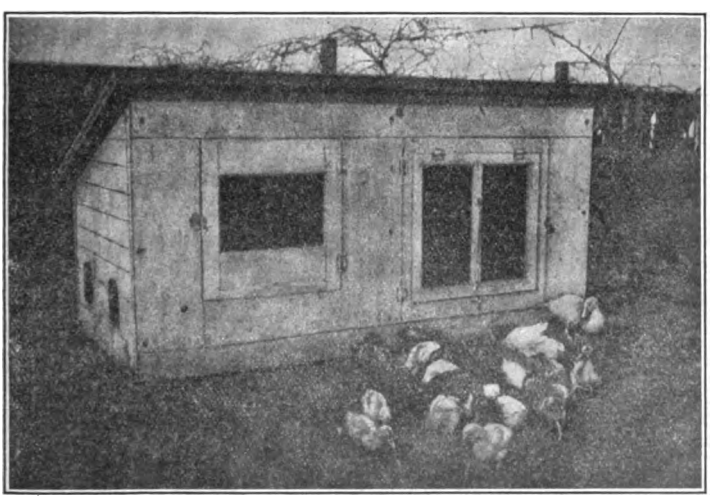

FIG. 24. A good style of outdoor brooder, giving plenty of room and light.

moisture necessary, but is often difficult to ventilate properly. Ventilation is an important point, especially if several machines are used at the same time, as the lamps use up a large amount of oxygen, and unless this is provided for the hatches are not apt to be satis-

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factory, either from the standpoint of the number of chicks hatched or the vitality of the chicks. A room partly under and partly above ground gives perhaps the best all round conditions, as here we get the advantage of the cellar in the matter of a constant temperature and a good supply of moisture, and the ventilation is much easier provided. Our incubator room is built in this way and is ventilated entirely from the windows, a cotton screen being fastened just outside the top half of the window and the windows lowered more or less, as weather conditions make necessary. The cotton screen allows the air to pass freely into the room without making a draft that would chill a machine or interfere with the lamps.

After setting up the incubator it is better to run it for a day or two before putting in the eggs, so that you may be sure that it is all right and that the regulator is working properly. When everything is running to your satisfaction put the eggs in and follow the directions sent with the machine. Don't think that you know more about it than the manufacturer does and try to run it as you or your friend have run some other make of machine or you will be apt to make a failure of it.

No matter whether it is the hen or incubator that is hatching the chicks, keep away from it at the time that the hatch is coming off. A hen is often worried by attention at this time and trampled chicks are the result. With the machine there is often a temptation to open it to help out a chick that seems to be having a hard time in getting out of the shell, and in doing so you injure a number of chicks to help one that will never amount to anything. A chicken that can not break the shell and get free himself is not worth saving.

When the hatch is over do not be in a hurry to move the chicks. They do not need any attention or feed for forty-eight hours and are better left in the machine or under the hen for this length of time. Care should be taken to see that the chicks do not get chilled.

If they are to be raised in a brooder, this should have been prepared by littering with finely cut clover or something of this nature, and being warmed up till the thermometer records ninety degrees under the hover. The addition of the chicks will raise the temperature to about ninety-five degrees, and it should be kept at this for the first week and then gradually reduced till the chicks are feathered and can do without heat. Water and sharp sand or chick-sized grit should be put in the brooder at the time that the chicks are moved. On the second day after they are hatched they may be given two light feeds, increasing the number of feeds one a day till they are getting five a day. Give only a little at a time and give it often, increasing the number of feeds rather than the amount given at a feed. This I believe is just as important as what you feed.

There are several feeds that are good for young chicks. It is hard to say which is best or that any one is best. I believe that in

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most cases a variety will give the best results. Rolled oats or the old-fashioned oat meal, finely cracked corn or wheat and an occasional feed of millet seed makes a good ration for chicks. These may be fed in rotation or mixed and fed together. A mixture of one part oat meal, one part finely cracked corn, two parts cracked wheat and one part of millet seed will make a good feed. This may be supplemented by one feed a day of cornbread made of two parts of coarse corn meal and one part of wheat middlings mixed with sour milk and a little soda and salt. Bake till thoroughly dry and crumble with hard boiled egg in the proportion of four parts of the bread to one of egg. At the end of two weeks substitute a dish of beef scrap for the bread and egg, continuing the grain mixture till the chicks are old enough to eat wheat and cracked corn, when they may be fed the same as the old stock. (See remarks on dry feeding on page 21.)

A plentiful supply of pure, fresh water should be before them at all times, and if, in addition, you can give all the skim milk that they will drink the beef scrap may be omitted.

Fig. 24 shows a good style of out-door brooder. The size is three feet by six feet, divided into two compartments by a removable partition. The left-hand end contains the hover and the chicks are better confined to this end for the first few days, when they may be allowed to go into the nursery end at will, care being taken to see that they find their way back the first day or two. The door on the

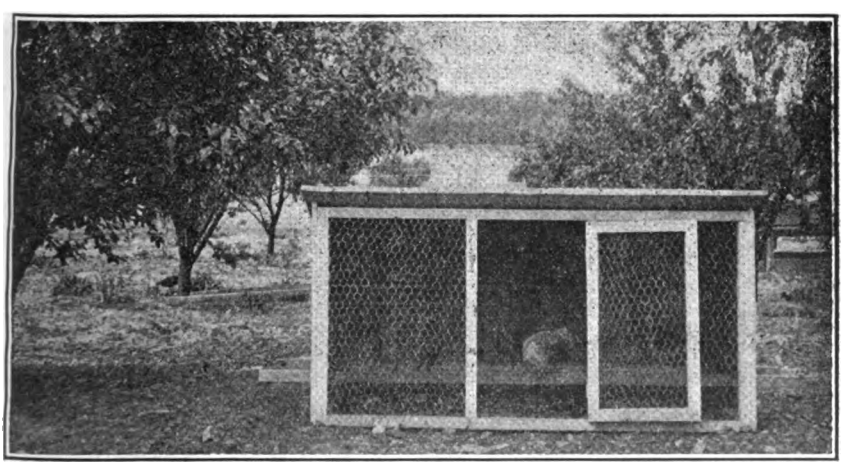

FIG. 25. A Roosting Coop, suitable for chicks from the time they are weaned till they go into winter quarters.

nursery is double, having glass and wire screening, so that the glass may be opened without the chicks being able to get out of the brooder, and in this way they can be gradually hardened to the outdoor temperature before being allowed outside.

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When the chicks are old enough to do without heat the partition and the heater may be removed, giving more room to the chicks.

When the nights become warm I prefer to substitute for the brooder the roosting coop, shown in Fig. 25, as it is more airy and still affords protection from storms, and can be closed to keep out dogs or other enemies of the chickens. This coop will be all that is necessary till the chickens are ready for winter quarters. I have wintered capons in one of these coops with good results.

HEALTH AND DISEASE.

I have tried to outline above a method of management that will reduce the loss from disease to a minimum. There is no place where the old adage, "an ounce of prevention is worth a pound of cure," is more true than in the treatment of disease in poultry. There are two reasons for this being so. In the first place the value of the individual hen is, in most cases, so small that it will cost as much or perhaps more to cure her than she is worth. Secondly, if you do cure her she should never be used in your breeding pen, as she will be very likely to transmit to her offspring the weakness that made her more subject to disease than the rest of the pen in which she was. The question, therefore, is more how to prevent disease than how to cure it.

Let me give you a few of the things that you can do to help in keeping your flock free from disease. Use for your breeding stock only birds that are strong and vigorous, fully matured and in the best possible condition. House this stock in a dry, well-ventilated, sunny house. Feed a variety of foods, including grains, animal food and green food; and lastly, but by no means least, keep the house clean and free from lice and mites.

I have mentioned before some of the indications of health and vigor in breeding stock, and also of the way to build the poultry house, and of some precautions that should be taken to help in the fight against lice and mites. I will say more here about these pests and how to get rid of them, as I am convinced that most of the troubles that we have with our fowls are due entirely to lice and filth.

Poultry parasites may be roughly divided into two classes: lice, which live on the fowls, and mites, which live in the house and attack the fowls when on the roost or in the nest.

The former are easier to fight, as they are found on the fowls, and can be killed by the use of insect powders, many of which are put up specially for use on poultry. A good powder can be made by using tobacco dust or even road dust, to which has been added a small quantity of napthalin flakes. Be careful not to use too much of the napthalin, as, while it will kill the lice, it will also injure the fowls. Young chicks are sometimes killed by being brooded by hens that have had a heavy dusting with a powder in which there is an

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excess of this material. Some of the special lice powders at present on the market have been causing trouble in this direction.

Mites are more dangerous, both on account of their being blood-sucking insects, and thus weakening the fowls very rapidly, and also because from their manner of living in the house and only attacking the fowls at night they are often present a long time before their presence is suspected. They are also harder to get at and kill, as they get into the cracks and crevices of the building and thus escape the means taken to destroy them.

They may be killed by thoroughly whitewashing the house with a wash to which has been added a teacupful of crude carbolic acid, creolin or a liquid lice paint to every five gallons of the wash.

Kerosene emulsion will also kill them and is cheap and easily applied with a spray pump. It is made by dissolving one pound of hard soap in one gallon of hot water and, while hot, adding two gallons of kerosene, and thoroughly stirring till cool. If you have a spray pump put the hot mixture into this, turn the nozzle into the can and pump it till cool. When wanted for use this stock may be diluted by the addition of seventeen gallons more water, making twenty gallons in all, of which two gallons, or ten per cent, is kerosene.

No matter whether you are dusting the fowls or spraying or whitewashing the house, the operation must be repeated to make a good job. In bad cases I would advise doing it three times at intervals of six days. In this way you get the second crop that have hatched from eggs that your emulsion did not reach.

To protect young chickens from the attacks of lice, especially the large head louse, grease the head and throat with lard. Try and have the hen free from lice when the chicks are hatched, and by greasing the head of each chick when it is put out with the hen and repeating the work in a week, the chick gets a good start. If you let a few of the head lice get on a young chick you may as well bury him at once, as he will, in most cases, die, and if he does not he will never amount to anything.

Serious losses with the chicks are often brought on by people continuing to raise them on the same ground year after year without taking any precautions to keep the ground from becoming poisoned.

Crop rotation is just as good practice in poultry raising as in any other branch of farming. Grow your chicks on fresh ground every year and put the last year's place in a crop to use up the droppings from the chickens. If you are obliged to use the same place year after year for the chicks see that a green crop of some kind is put in as soon as the chicks are off it, and let it grow till wanted for next year's chicks.

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Bulletin No. 196 **June 1907**

NORTH CAROLINA

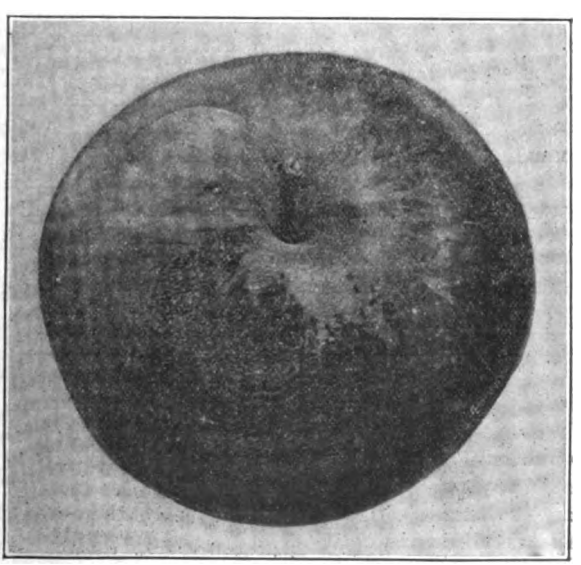
Agricultural Experiment Station

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

WEST RALEIGH.

SOME APPLE DISEASES



THE VOLUTELLA ROT

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THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

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PRACTICAL SUMMARY.

Several apple diseases, part of them not heretofore recognized, are described in this bulletin. They consist of two fruit rots, two twig blights and a bark disease which is called the scurf.

These diseases are all caused by fungi and are therefore probably amenable to treatment with the ordinary sprays. The existence of some of these fruit rotting fungi in winter upon twigs indicates the necessity of carefully pruning out all dead twigs to prevent infection of the fruit, and of other twigs, in following seasons.

Spraying, rendered necessary by old and too well known apple diseases, is made doubly important by the discovery of these new enemies to apple culture.

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THE VOLUTELLA ROT.[1]

BY F. L. STEVENS AND J. G. HALL.

A black rot of apples, closely imitating in appearance that caused by Sphaeropsis, but differing from the Sphaeropsis rot in several details, has been observed frequently in various sections of this State, on native apples and on apples shipped into the State from a distance.

In general appearance the disease consists of a rotten black spot, frontispiece, the spot increasing in size until it eventually encompasses the whole fruit. The central and older portions of the decayed region are of an intense coal black color. The younger region of the spot, its outer border, a zone about five-eighths of an inch wide, is brownish.

Close inspection reveals the presence of slightly elevated pimple-like places in the cuticle. These are found to within about one-fourth of an inch of the edge of the spot, and become larger and more pronounced as the center of the spot is approached, indeed, the black color of the spot seems to be due to the thick setting of these black pimples all over its surface. In many instances, unless the spot be quite old, no other development is seen, and the disease might readily

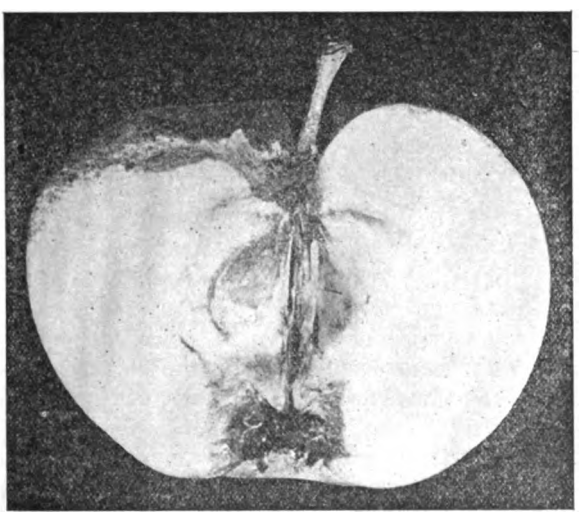

FIG. 2. The Volutella Rot in Section.

be considered to be the ordinary black rot, caused by Sphaeropsis, and doubtless often passes for it. In older spots, however, the pimples

[1] Published in part in Journal of Mycology vol. 13, p. 94, May, 1907.

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are seen to have broken through the cuticle of the apple, and each pimple appears as a small wart-like excrescence, and a good lens shows that it is thickly beset with stiff black hairs. These hairs constitute the distinctive character of this disease, and serve to separate it with ease and certainty from the Sphaeropsis rot, provided the rot is developed far enough to exhibit this character.

On slicing the apple open it is seen that the zone most recently invaded is brownish, while all of the older portion is black. (Fig. 2.)

While the decayed portions are softer than the healthy, this is in no sense a wet rot, the softness being due to a spongy dryness rather than to any watery breaking down of tissue. Upon microscopic examination the cells of the old dark, diseased portion of the apple are found to be filled with a tangled mass of black or dark brown fungous threads (Fig. 3), which are richly septate and much branched. In

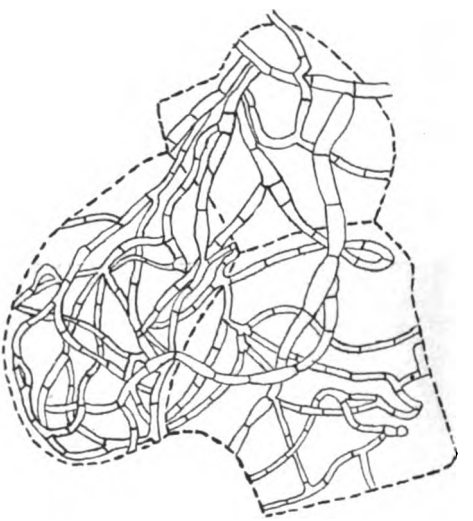

FIG. 3. Cell Invaded by Mycelium.

thickness they vary from 5 to 7 Mu[1] in the older portions. In the newly invaded cells the mycelium is usually only about 2 Mu thick and is colorless.

As the spot ages the mycelium develops more abundantly in a few layers of cells next to the cuticle, particularly immediately under the cuticle. From this sub-cuticular layer of tangled mycelium there develops a cushion of hyphae, which are arranged parallel and stand upright, perpendicular to the substratum. These hyphae are quite uniform in thickness and regular in arrangement, composed of short

1 1 Mu equals 1-25,000 of an inch.

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rectangular cells. (Fig. 4.) These upright hyphae increase in length, rupture the cuticle and develop the tubercular mass, (Fig.

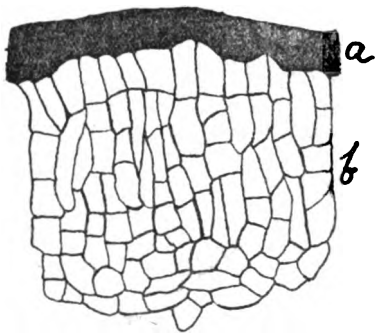

FIG. 4. Palisade Arrangement of Hyphae.

5), "sporodochium," characteristic of the fungous order Tuberculariales. The tubercle attains a height of 100 to 125 Mu and a diameter nearly twice as great. About midway from base to top of the sporo-

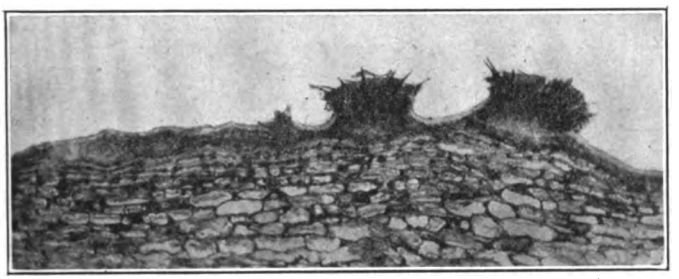

FIG 5. Sporodochia in Section.

dochium the hyphae become narrower and the setae have their insertion (Fig. 6). The setae develop directly from hyphae which stand amid sporogenous hyphae and are indistinguishable from them, their only point of difference being that the setigerous hyphae broaden out at the end and develop into typical setae while the sporogenous proceed to spore development. Each setum is produced from the tip of a single hypha. The setae are from 100 to 400 Mu long, tapering gradually from base to tip. At base they are 5 to 8 Mu broad. They have from 2 to 5 septa (Figs. 6 and 7).

At the upper end of the erect fuscous or black hyphae, which constitute the sporodochium, are simple, slender hyaline stalks, "conidiophores," from 25 to 35 Mu x 3 Mu long, which bear the spores (Fig. 8). The conidiophores together constitute the outermost layer of the sporodochium.

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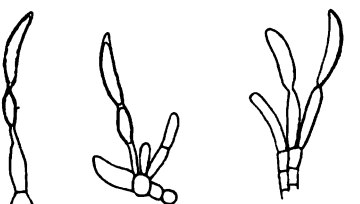

FIG. 8. Basidia and Spores.

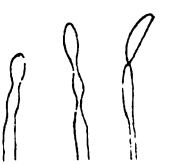

FIG. 9.
Basidia and Spores

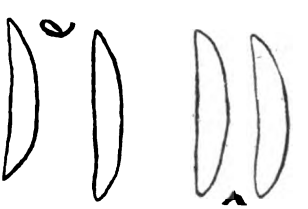

FIG. 10. Spores.

FIG. 6.
Showing Origin of Seta.

FIG. 7. Seta and Septae.

The spores are produced acrogenously, being cut off from tips of the conidiophore by a constriction of the fertile hyphae (Fig. 9).

The spores are oblong-fusoid to falcate-fusoid, with acute ends (Fig. 10), hyaline or very slightly olivaceous, continuous, though with the low power of the microscope they often appear uniseptate,

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due to peculiarities of the protoplasm in this region. They measure from 17 to 23 Mu long by 2.5 to 3.5 Mu broad.

Placed in apple agar in hanging drop cultures they germinate in about three hours. At first by a single hyphal thread near one end of the spore (Fig. 11), but later other points of germination can be seen. When germination begins the spores become very coarsely granular. The granules then become fewer in number and larger as germination proceeds. Later, by the migration of the granules into the young hyphae, clear spaces appear. At first there are no septae in the hyphae, but after about 25 to 30 hours a swelling is usually seen at the end of the hypha (Fig. 11), which soon becomes cut off by a wall. This cell rapidly assumes a dark color and has the appearance of the secondary spores, so characteristic a feature in the germination of the anthracnoses. As with the anthracnoses this body may remain without further development or it may germinate immediately (Fig. 12). The growth of the hypha is slow, as shown by Fig. 11. These drawings were made from the

FIG. 11. Germinating Spores.

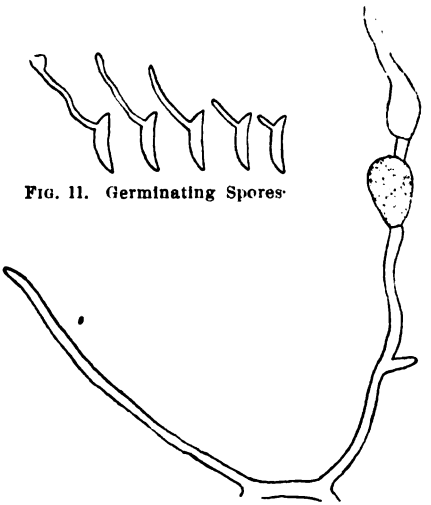

FIG. 12. Germinating Spore and Secondary Spores.

same spore, growing in a hanging drop culture, at periods of one hour.

Transfers into solidified pea agar and apple agar plates were made under aseptic conditions from the regions immediately beneath the skin in a diseased spot; also from the diseased tissue near the boundary between diseased and healthy portions, and in every instance pure cultures of the fungus were obtained. By plating from water containing many of the spores pure cultures were also obtained.

When grown in media containing starch or glucose the mycelium of the fungus is densely black. In the absence of these nutrients it

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is colorless. In none of the artificial cultures were spores formed. On sterilized apple twigs, however, spores were produced in abundance.

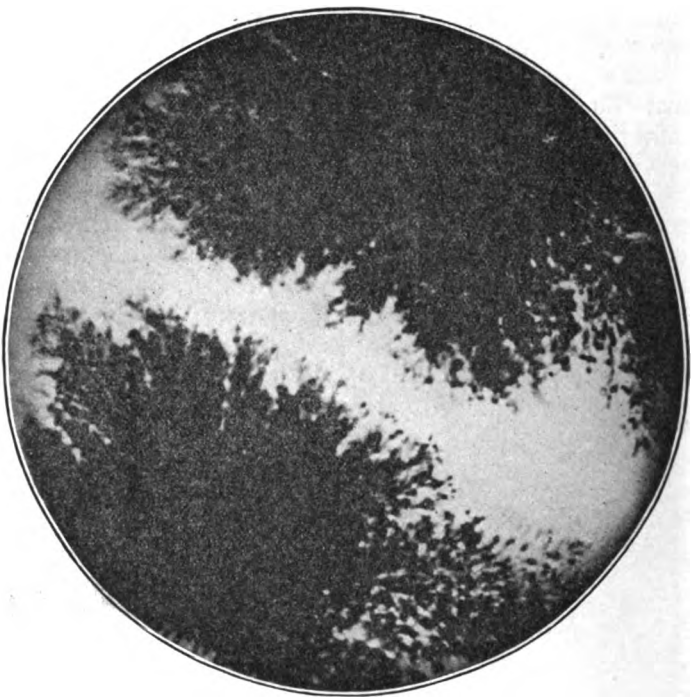

FIG. 13. Colony on Medium Rich in Carbohydrate

The effect of carbohydrate upon the color of mycelium is most strikingly brought out in petri dish cultures, as is shown in the accompanying illustration, representing colonies grown upon pea agar and colonies grown upon apple agar. Upon apple agar the colonies are densely black throughout (Fig. 13). Upon pea agar they are colorless, the only blackening being located in scattered spots (Fig. 14).

Inoculations were made from mycelium grown in pure culture by pricking the skin of the apple and laying on, or inserting, a bit of the mycelium. Within nineteen days of the inoculation the spot had attained a diameter of seven-eighths of an inch. The accompanying illustration (Fig. 15) shows the rapidity of development in one instance at room temperature, 101 hours intervening while the rot progressed from the inner to the outer inked circle.

Many attempts were made to secure inoculation through unbroken cuticle, but in no instance with success. It is evident that a bruise or break of some kind is necessary. This evidence correlates well

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with the fact that the disease, as is true of so many fruit diseases, is much more common at the blossom end or the stem end than at other points. The rot occurs at either end of the fruit more often than elsewhere, because it is at these places that the cuticle is most liable to injury.

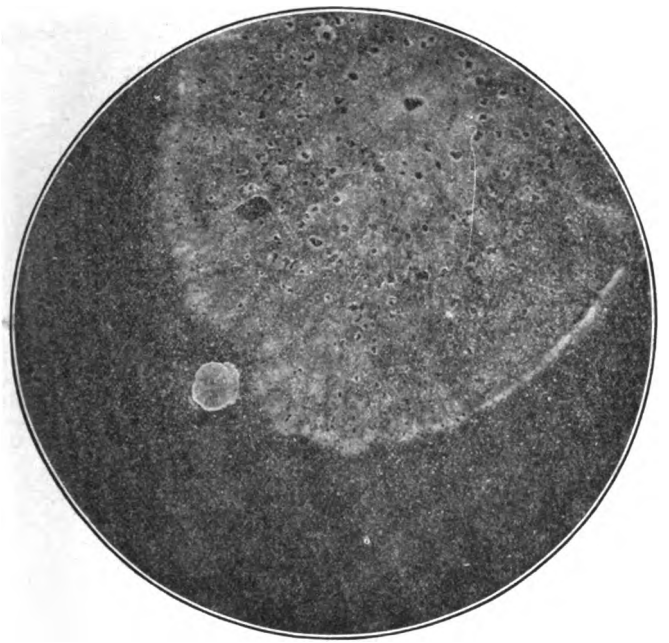

FIG. 14. Colony on Medium Poor in Carbohydrate.

The tubercular development places the fungous unquestionably among the Tuberculariales. Further, the road is not so clear. Judging strictly from the color of the mycelium it must go to the Dematiae, but a glance over its possible kin there reveals none which are of certain affinity. Admitting that it is possibly of the Mucedineae, it clearly must belong to the genus Volutella. This genus is made up mainly of light colored fungi, though several of them are very dark, notably V *Acalyphae, oxyspora, Violae, Citrulli* and *Allii*. From a structural viewpoint this fungus seems much closer to Volutella than to any of the Dematiae, and in view of the purely physiological nature of the color character, as shown by our cultures, it being dependent upon the presence of carbohydrates (which are present in abundance in the natural medium, the apple), we believe we are doing no violence to facts in placing it in the genus Volutella.

As a Volutella it stands closest to the species named above, yet is dstinct enough from them to be regarded as a separate species.

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It differs from *Oxyspora* in larger sporodochia 150-400 Mu and longer setae, shorter spores, longer basidia; from *Cittrulli* in shape of spores; from *Allii,* sporodochia larger, not convex or elongate, setae

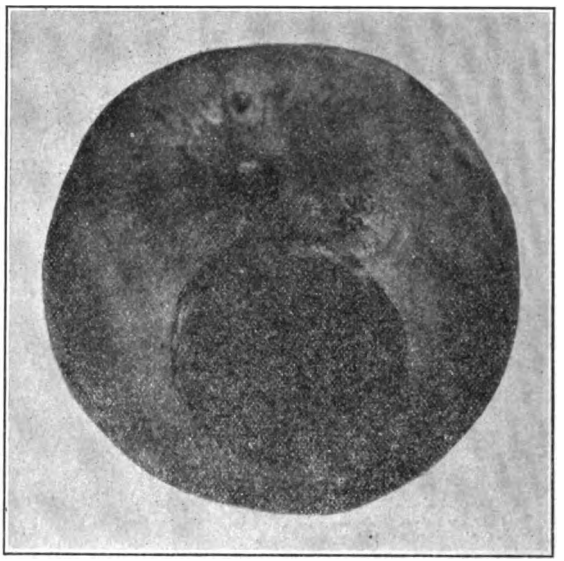

FIG. 15. Showing Rapidity of Development.

longer; from *Violae*[1]; in character of sporodochium; from *Acalyphae* in size of spores.

VOLUTELLA FRUCTI. STEVENS AND HALL.[2]

Sporodochia numerous in concentric circles early sub-cuticular, then erumpent, elevated from 200 to 250 Mu black. 150-400 Mu in diameter mycelium, black in presence of carbohydrates, otherwise hyaline.

Setae; distributed throughout sporodochium, black 0-3 septate, acute, smooth, 100-400 Mu long, 5 to 8 Mu thick.

Sporophores; elongate, hyaline, simple, 25-35 x 3 Mu.

Conidia; hyaline or very slightly olivaceous, continuous, smooth, oblong-fusoid to falcate-fusoid, 17-23 x 2.5-3.5 Mu.

Habitat; Fruit of *Pyrus Malorum,* North Carolina, Type N. C. Agricultural Experiment Station, No. 780.

TREATMENT.

It is probable that the sprayings usually recommended for scab and black rot will be effective in controlling the Volutella Rot.

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[1] See Bot. Gaz., XXVI, Pl. XIV, 85.

[2] Originally described in Journal of Mycology 13, p. 91, May, 1907.

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CONIOTHYRIUM AS A FRUIT ROT.

This fungus has frequently been seen causing rotten spots in apples in this State. It was first made the object of study in this laboratory in November, 1906. The rotten spot is circular in uniform tissue, brownish, about the color of the common Penicillium rot and, due to loss from evaporation, the tissue shrinks as the spot ages, leaving the surface much wrinkled (Fig. 1). Distributed somewhat sparsely

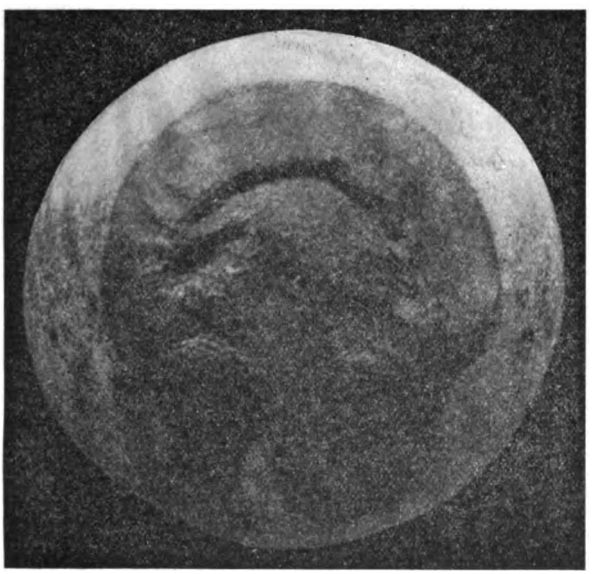

FIG. 1.—Coniothyrium Rot.

and irregularly over the spot are the fruiting cavities of the fungus "pycnidia." In rotten spots produced by inoculation the pycnidia frequently assume a somewhat concentric arrangement. Proceeding from the innermost pycnidia toward the edge of the spot the pycnidia become smaller, none at all being found nearer than about 5 mm. to the edge of the diseased tissue.

Upon sectioning through a diseased spot the flesh of the fruit is

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seen to be rotten, brownish and soft (Fig. 2), not black or dry, as is the case with the Volutella Rot.

Microscopic examination shows the diseased tissue to be thoroughly

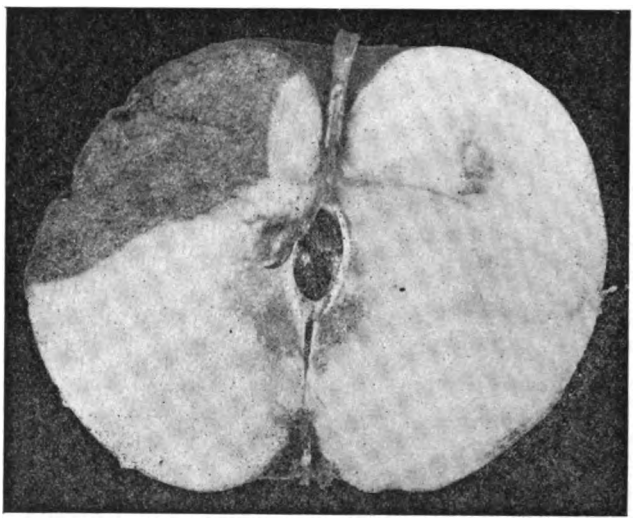

FIG. 2.—Coniothyrium Rot in Section.

invaded with a thin branching septate mycelium which, when young, is hyaline, when old fuscous or straw colored.

The fruiting bodies lie immediately under the cuticle and consist of spherical cavities about 200 Mu in diameter, walled in by a weft of mycelial threads. When mature this pycnidium bears very numerous small black or brown spores 3-5.8 x 2-2.5 Mu (Fig. 3), approximately 250,000 spores being borne in a single pycnidium. The spores are borne on stalks standing perpendicular to the wall of the pycnidium and extending toward the central cavity.

FIG. 3. Coniothyrium Spores.

As the spores accumulate pressure is exerted upon the cuticle, causing its rupture, and the spores are freed. Frequently, if the cuticle be thick, the pycnidia open under the cuticle and the spores are unable to escape until further disintegration proceeds.

The fungus is clearly a species of Coniothyrium and agrees well in all of its characters with C. *Fuckelii* Sacc. Although that species is recorded as inhabiting branches only, it is probable that it is iden-

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tical with the form in question. Isolation of the fungus for the purpose of more closely studying its character was easily affected by breaking a pycnidium in sterile water and then using a cubic centimeter or so of the solution in each tube of the medium used for plating; other isolations were also made by making transfers to poured agar plates from the flesh just underneath the epidermis of the diseased spot.

In artificial culture on pea agar the fungus grows rapidly, producing a pure white mycelium. On apple agar the mycelium is tawny. Pycnidia developed upon plate cultures with extreme rarity, many cultures showing no pycnidia whatever, others a very few. In all instances where they were produced it was as the fungus became old and the agar dense or nearly dry. In some instances their arrangement upon the plate was strikingly regular and inexplicable. In one plate (Fig. 4) an almost perfect circle of pycnidia was formed at a distance of about 2.5 cm. from the point of inoculation, and

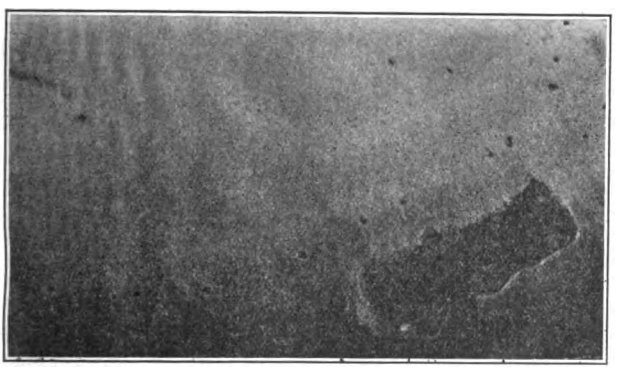

FIG. 4.—Coniothyrium Showing Arrangement of Pycnidia.

though the mycelium proceeded to grow beyond this point no further pycnidia formation occurred.

Inoculated upon sterile apple twigs the mycelium was dense and white and pycnidia were produced in abundance.

CONIOTHYRIUM ON APPLE TWIGS.

Many instances of this fungus occurring upon apple twigs have come under observation during the past year. The affected twig, usually terminal portions of recent growth, dies, the bark shrinks and shrivels, turns black and at the line of demarkation between diseased and healthy tissue cracks. (Fig. 5.) The general appearance of such a twig is much like that caused by the fire blight, but is readily distinguished by the presence of very numerous, minute, pimple-like pustules, the pycnidia, distributed over the dead part.

The significance of this fungus upon twigs is twofold: 1, as a

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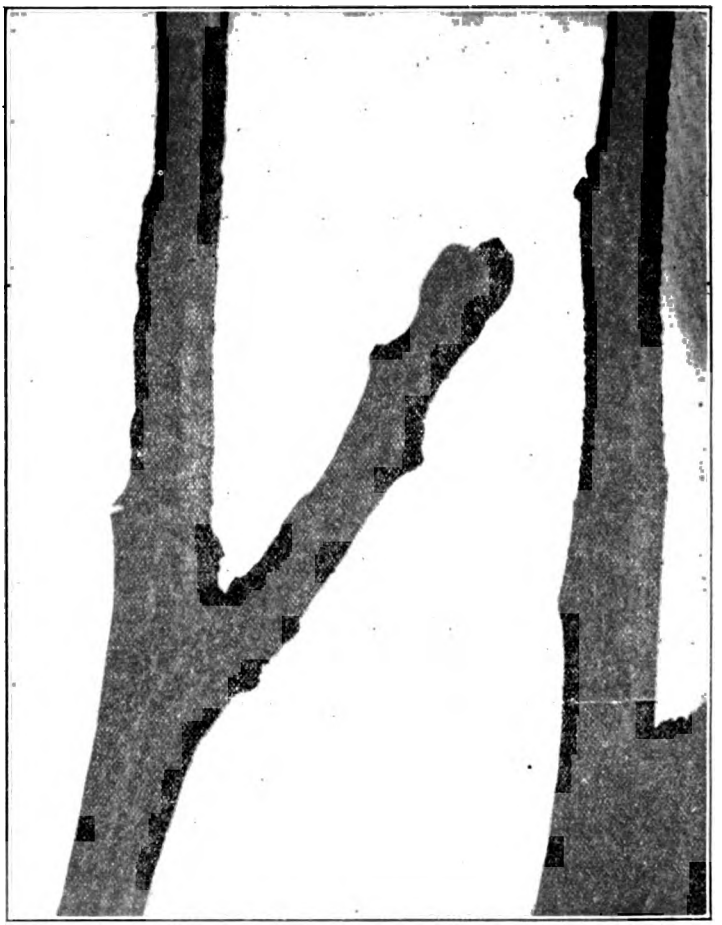

FIG. 5 —Coniothyrium.

cause of the twig blight, 2, as a source of infective material, spo .s, to transmit the rot to the fruit.

TREATMENT.

Spraying coupled with careful pruning out and burning of diseased twigs and branches will doubtless serve as a means of control of Coniothyrium both upon branches and fruit.

SPHAEROPSIS ON APPLE TWIGS.

This fungus, long known as the cause of the black rot,[1] of the fruit and later as the cause of cankers of the limbs,[2] frequently occurs

[1] Peck 34th Ann'l Rept., p. 86, 1881. [2] Paddock N. Y. Exp. Station Bulletin, 168, Dec., 1899.

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To determine with certainty whether this fungus was the true cause of the scurf, also whether it could gain entrance through uninjured bark, a series of inoculations was made upon the apple trees growing at the Station farm.

Some three hundred inoculations by Mr. W. F. Kirkpatrick and Mr. S. W. Foster were made by cutting from agar plates, with a sterile knife, small squares of agar bearing the fungous threads. Inoculations were made upon bruised bark and upon unbruised bark, resulting in the production of the typical diseased condition in 49.4 per cent of the inoculations upon bruised bark and only about 3 per cent of infection upon uninjured bark. While definite proof is lacking, it is probable that all infections upon unbruised bark were through lenticels.

TREATMENT.

Spraying and close pruning of affected branches will probably lead to control of this disease.

ERRATA.—Transpose pages 53 and 55.

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APPLE SCURF.[1]

BY F. L. STEVENS.

This is the name proposed for a disease which does not seem to have been heretofore described in the literature of apple diseases. The disease has been under observation for about two years in this Station, it having been sent to the Station with inquiries from two different sections of the State during that time.

The first specimen was received from Watauga County, N. C., in May, 1905. The chief symptom is a shrinking of the bark, including the epidermis, in such manner that minute air spaces are left immediately below the cuticle, giving to the affected region a silvery gray appearance. Close examination, especially with the aid of a lens, shows the presence of myriads of minute black pycnidia scattered throughout the affected region. Such a condition may extend over large areas on twigs one, two or three years of age. The seriousness of the disease, the amount of damage done, is unknown. That the condition has attracted the attention of practical apple growers to sufficient extent to cause them to submit specimens for diagnosis indicates that the injury is at least appreciable to the apple growers of the State. Death of the infected twigs does not always seem to follow infection. The disease is limited to the bark and would, therefore, be slow to cause death, and if it did it would be only through injury to the tree as a whole and would be gradual and insidious.

The black pycnidial bodies, referred to above, were found to contain minute spores, elliptical or oblong in shape, hyaline and about 2 x 5.8 Mu in size. The pycnidia were 100 to 125 Mu in diameter, black and provided with a minute ostiolum, from which the spores issue in coils upon being wet. The fungus clearly belongs either to the genus Phyllostica or Phoma, of which there are at least 22 species reported as growing upon the apple or its close kin. Since this species agrees closely with the description of P. *prunicola,* except in slight details, as regards the spot produced, and in the fact that P. *prunicola* is a leaf fungus, it seems best to regard it as being that species. Plate cultures in apple bark agar were made from spores in the spring of 1905, leading to a ready isolation of the fungus, which grew rapidly upon this medium.

It fruited in abundance, producing its characteristic pycnidia and spores. The colonies, owing to the color of the mycelium, were of a striking brick-red color.

1 Attention was called to this disease at the Spring Meeting of the North Carolina Academy of Science in May, 1905, and in the Report of the Biological Division in the Annual Report of this Station for 1904-'05, pp 20, 21.

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on apple twigs as a cause of blight. Several cases came under observation in this State in 1905 and were reported in the annual report of this Station. They have also been noted by Rolfs.

In general appearance Sphaeropsis on twigs is precisely like that of Coniothyrium, as described above, with the possible difference that the pycnidia are larger and less numerous. The two can not, however, be safely distinguished without microscopic examination.

TREATMENT.

The presence of Sphaeropsis as a twig blight as well as a canker causing fungus serves, as in the case with Coniothyrium, to give this fungus wider dissemination, and indicates the necessity of most careful pruning to thereby lessen the possibility of fruit infection, as well as to prevent injury from the fungus as a twig blight.

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The N. C. Agricultural Experiment Station 1907—1908

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THIRTY-FIRST ANNUAL REPORT

OF THE

NORTH CAROLINA

Agricultural Experiment Station

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

FOR THE

Year Ending June 30, 1908

Including Scientific Papers and Bulletins Nos. 197, 198, 199

West Raleigh, North Carolina

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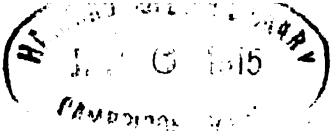

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE

GOVERNOR R. B. GLENN, *ex officio* Chairman, Raleigh

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STATION STAFF

GEORGE T. WINSTON, President of the College

C. B. WILLIAMS.....Director and Agronomist
W. A. WITHERS.....Chemist
F. L. STEVENS.....Vegetable Pathologist
J. S. JEFFREY.....Poultryman
F. C. REIMER.....Horticulturist
R. S. CURTIS.....Animal Husbandman
JOHN MICHELS.....Dairy Husbandman
R. I. SMITH.....Entomologist
WILLIAM KERR.....Assistant in Field Experiments
W. A. SYME.....Assistant Chemist
J. G. HALL.....Assistant in Plant Diseases
W. C. ETHERIDGE.....Assistant in Farm Crops
J. C. TEMPLE.....Assistant Bacteriologist
A. F. BOWEN.....Bursar
C. P. FRANKLIN.....Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION.
WEST RALEIGH, N C

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North Carolina Agricultural Experiment Station,
Office of the Director,
West Raleigh, N. C., June 30, 1908.

To His Excellency, Robert B. Glenn,
Governor of North Carolina.

Sir:—I have the honor to submit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts for the year ending June 30, 1908.

Trusting that this report will prove satisfactory to your Excellency, I am,

Yours very truly,

C. B. Williams,
Director.

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THIRTY-FIRST ANNUAL REPORT

OF THE DIRECTORS OF THE

N. C. AGRICULTURAL EXPERIMENT STATION

For the Year Ending June 30, 1908

BY THE DIRECTOR

Upon assuming the duties of Director of the Station at the beginning of the year, careful consideration with the different workers was made of plans of all experiments being conducted and of those subsequently inaugurated. In all branches of the Station new and important lines of investigation have been started, and this work in most cases is progressing in a satisfactory manner. Herewith is presented a brief statement regarding the work in progress in the several Divisions of the Station, which is made up partly from the reports of the different workers and partly from observations made by the Director.

DIVISION OF AGRONOMY.

The experimental work of this Division has been materially augmented and strengthened during the year, both by the addition of new lines of work and by the extension of experiments in progress. Much attention is being devoted to a determination of the best fertilizer combinations and the most economical quantities to use per acre; the most prolific varieties; the best methods of cultivation and handling; and the most profitable rotation for corn, cotton, wheat, oats, cowpeas and soy beans, for the conditions of climate and soil under which the experiments are being conducted. Experiments are being carried on to ascertain the best fertilizer and lime treatment for legumes. With oats, varieties are being grown both from fall and spring sowings to determine the relative value of these different sowings and the best varieties to use for seeding at the respective seasons. Much work has been put out to aid in study of the effect of proper methods of seed selection of cotton, wheat and corn upon their prolificacy and yield. This year, the variety tests will embrace a comparison of sixty-eight varieties of corn, thirty-eight of cotton, fifteen of wheat, sixty-two of oats and about fifty of cowpeas and soy beans. In addition to these, variety-distance tests are being conducted with three leading typical varieties of corn and three of cotton to determine the optimum distancing of these when grown under different conditions. In response to a popular demand for information on alfalfa and clover growing, field studies on small plats are being made to determine under what

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conditions of soil, fertilization and cultural management these different legumes make their best and most profitable growth. Investigations are being conducted to ascertain the factors which promote the growth of suckers on different varieties of corn, and the relation their undisturbed development sustains to total yield of grain per acre. More than fifty combinations of grasses and legumes are being experimented with to study their comparative value for hay and pasturage. A thorough system of terraces over the whole farm has been laid off and constructed at an expenditure of considerable effort and time.

DIVISION OF CHEMISTRY.

The Chemical Division has maintained a close cooperation with the Biological Division in a study of nitrogen-fixation, ammonification, nitrification and denitrification. In this cooperation the Chemist confines his attention to the chemical analyses, while the Bacteriologist looks after the bacteriological examinations. Efforts are being made to determine the nature, distribution and conditions most and least favorable for the growing of nitrogen-fixing, nitrifying, ammonifying and denitrifying bacteria. In these investigations, an especial effort is made by the Bacteriologist to isolate and identify the bacteria concerned.

DIVISION OF BIOLOGY.

The research work of the Biological Division has progressed actively along the same general course as previously reported, but has been greatly enlarged by the extension of old lines and the addition of new ones. The cooperation which has been maintained by this Division with the National Bureau of Plant Industry in a Plant Disease Survey of North Carolina and in an effort to secure melons of high eating and shipping qualities that could be grown upon land affected with watermelon wilt will be continued, and experiments have been put out on a badly infected field near Auburn. Efforts are being directed largely toward the production by hybridization and selection of strains of melons that will be wilt-resistant. The results obtained along this line during the past year have been exceedingly encouraging, as the wilt-resistant melons, which now comprise practically all that are being worked with, have been found to possess decidedly higher edible and commercial values than has been secured heretofore.

The tobacco wilt experiments which have been conducted for a number of years in the old bright tobacco belt of Granville County, for the purpose of securing wilt-resistant strains of high commercial value, will be continued. Up to this time, the resistance to this disease of about seventy varieties has been determined. On the infected areas native types of tobacco are practically wiped out by the ravages of this disease. Attention is being confined this year in these ex-

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periments to a study of six highly resistant strains, the resistance of which was brought out by last year's work. These promising strains which have been developed are two from Sumatra; two from Turkish; one from Italian; and one from local bright leaf tobacco.

The study of fungi or bacteria causing new or little known apple diseases, occurring in the State, have been continued and extended. During the period covered by these investigations, two new diseases have been discovered and several new ones have been described and much information concerning their mode of life, relation of plant growth and best methods of treatment has been worked out and published. For the present in this line of work, attention is being confined largely to morphological and physiological studies of apple rot, canker, leaf-spot and two diseases that affect the twigs, with the hope of evolving practical remedial measures.

In the lettuce drop investigations, by the construction of cold frames on the Station farm, it has been possible to prosecute the work more completely under control conditions. Outdoor experiments are being carried on which are designed to determine the longevity of the vegetative and reproductive parts of the causal fungus in the soil and in the atmosphere; under what conditions the spores infect the leaves; and the resistance of the fungus to treatment by different chemicals in varying concentrations. These experiments are being supplemented by laboratory work. The soil bacteriology investigations in cooperation with the Chemical Division have been enlarged and continued. A large number of organisms have been isolated and studied with a disclosure of the extreme variety of the presence of nitrifying power in most soils worked with. Study is being made of ammonifying organisms and the comparative rate of activity of nitrogen-fixing bacteria in soils and in solutions. Efforts are being directed towards determining the relative availability and acceptability of ammoniacal nitrogen to some of our general farm crops as compared with nitrate nitrogen. During the year, new research work on the development of poisons in milk has been started for the purpose of ascertaining the conditions under which these are produced and to determine from what source bacteria producing the toxins are derived. Attention will be given to an isolation and study of the organisms responsible for the production of these toxic principles. This work, with slight modifications, will be continued. The value of the work of this Division is attested by the large correspondence it maintains with farmers and fruit growers on plant diseases.

DIVISION OF POULTRY.

Work in the main of the Poultry Division has been conducted along the general lines of testing the relative efficiency of different breeds in food utilization, as shown by egg-production and increase in weight; various methods of handling and feeding chickens; and

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different styles of incubators and brooders under different systems of management. In the pedigreed breeding experiments which have now been conducted for two years the results seem to indicate an increased percentage of good layers over previous years. With careful and intelligent breeding and selection along the right lines it is expected to secure strains of greater prolificacy; of higher percentage of egg hatching; and of hardier and more robust constitution. Experiments to determine the value of disinfecting incubators and adding moisture artificially have been carried on with six machines. There seems to be a material increase in the percentage of chickens hatched from fertile eggs under these two conditions combined or separately over those hatched made in dry machines, although the incubators used were of the non-moisture type. In this connection it might be mentioned that the poultryman has secured in these moisture and disinfection experiments two hatches which have proven to be decidedly the best ones that have been made during his five years connection with the Station.

Feeding experiments have just been started to test the value of cottonseed meal for poultry feeding, when fed in different quantities and in different combinations in conjunction with corn and wheat bran. A study of the effects of inbreeding in poultry is being made to determine if it can be carried on indefinitely without producing deterioration in the flock in point of prolificacy, size and vigor, if due attention is given to these characters in mating and selecting breeding stock. This work has not progressed very far, but at this time a marked improvement in the laying capacity of many individuals has been noted.

DIVISION OF HORTICULTURE.

The Horticulturist has devoted his attention largely during the past year to outlining and getting started work of an original nature with blackberries and dewberries. At present he is confining his energies chiefly to a study of the causes and best methods of treatment of that fasciculation commonly known as "double flower," to which these are subject wherever grown commercially in North Carolina. The investigations will consist largely of a study of the structure and growth of the fascicle to determine the causes for its formation, whether due to disease, insects, physiological conditions, cultural treatment, soil or weather. The growing of blackberries in this State for market purposes was started in a small way about twenty years ago in the section around Ridgeway. From this modest beginning, the growing of these and dewberries has gradually developed, until to-day the sale of these crops bring thousands of dollars into the communities where this industry is carried on and where a few years ago there were practically no horticultural interests. This

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industry is centered chiefly in Warren, Moore, Cumberland, Columbus and Harnett counties, and is established in many cases on soils which are now returning annually in profit per acre fifteen to twenty times the original purchase price of the land. There are thousands of acres of sandy and sandy loam soils located in the coastal plain section of the State which, as they are at present affording little or no income to their owners, may be purchased very cheaply and which might be given over to remunerative blackberry and dewberry culture. At present, one of the most serious drawbacks to the maintenance and extension of this branch of farming is the greatly decreased yield, frequently caused by "double flower" or "rosette." Especially menacing to profitable blackberry growing is the reduced production experienced by many growers. The Wilson blackberry, the only variety grown for general market purposes, because of its appearance, edibility, shipping qualities and its date of maturity, is ordinarily so badly affected with sterility in the large number of abnormally developed flower parts as to suffer usually a reduction of about seventy-five per cent in total yield. The trouble, while not nearly so serious with dewberries, can only be held in check by costly cultural methods, such as cutting off all the young canes immediately after the picking has been finished. The determining of the cause of "rosette" will have wide practical bearing on the working out of remedial measures not only for blackberry and dewberry growers in North Carolina, but for those located in other sections of the country where these are affected with this abnormality of growth.

The work which this Division is conducting on anthracnose and self-sterility in dewberries is fraught with economic features and possibilities.

DIVISION OF ANIMAL HUSBANDRY.

As this is a new Division of the Station, a considerable portion of the time of the Animal Husbandman has been taken up in planning, providing animals and new equipment and getting under way lines of experimentation. No phase of the work has been completed, but all that has been started is being prosecuted as expeditiously as is consistent with expediency. Much effort has been devoted to a study of the effects of feeding cottonseed meal and linseed meal as supplementary feeds to corn to young and thrifty pigs with a mean average of about 100 pounds live weight, during the experiments. These experiments are designed to determine the amounts of cottonseed meal, which may be safely fed in conjunction with corn to hogs; the economy of gains made; and the quality of the pork produced, in comparison with that secured with rations of corn alone and corn and linseed meal combined. With the completion of the first half of the experiment which had been running for ninety days, it was demonstrated that 0.6 pound of cottonseed meal mixed with the other por-

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tion of the ration and fermented may be fed safely during this length period in conjunction with corn in the proportion of five parts of corn to one of meal and secure a pound of gain at less than one-half the cost of those obtained by feeding corn alone under the same conditions. A combination of linseed meal with corn in the proportion of one to five produced gains at about one-half the cost of corn fed alone; in other words, this lot by eating a little more than one-third more feed made three and one-third the amount of gain in the same length of time. These experiments which have been conducted with hogs confined in pens will be duplicated, using the same feeds combined in the same way, with hogs allowed to range on different green crops, such as rape, rye, etc., alone and in combinations. Also, cottonseed meal feeding experiments have been started with the mules and horses which are being worked on the farm. During the preliminary periods, after a few days trial, they have been found to eat from one to one and one-half pounds of meal per day with relish.

DIVISION OF DAIRY HUSBANDRY.

A portion of the time of the Dairy Husbandman has been taken up in conducting feeding experiments to determine the relative value of cottonseed hulls and corn stover as roughages; and dried brewers' grains, and crushed corn in conjunction with cottonseed meal as concentrates with corn stover as the sole roughage for milk and butter production. The first part of these experiments has been finished and show that inferior corn stover, which product is usually left in the field to rot, still had a feeding value for dairy cows equal to that of cottonseed hulls. As a result of a carefully conducted experiment in calf-feeding, it has been demonstrated that a reduction of about sixty per cent in the cost of feeding young calves during the first fourteen weeks may be effected by a gradual substitution of rolled oats for whole milk after the first week when fed in conjunction with a grain ration consisting of one part each of corn meal, linseed meal and wheat bran after the fourth week. The practical bearing of these results will be appreciated when it is considered that one pound of rolled oats, costing about four and one-half cents, contains the same nutritive value as one gallon of milk, which will sell for thirty to forty cents. Some effort has been given to planning and constructing an ice-box, a milk and cream cooler and a sterilizer that would be cheap and efficient for small dairies. With each of these as devised greater efficiency has been secured at greatly reduced cost over the means and appliances ordinarily employed. The cooling investigations have brought out the fact that to a large extent the delivery of the milk may be made entirely independent of the time of milking. Milk kept cool for fifteen hours before delivery has been found to reach the consumer in better shape than milk taken

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from the same cows under the same conditions and put into his hands immediately upon milking without cooling. The value of these results will be appreciated by dairymen who have had to begin milking at two to three o'clock in the morning in order to have their product come upon the market in satisfactory shape, because the milk handled in the usual way will only keep in good condition for a very few hours, especially during the summer months. By cooling to 45 degrees Fahr. and keeping the milk at this temperature, delivery may be delayed for twenty-four hours under the most trying weather conditions, thereby obviating the absolute necessity for milking earlier than a convenient hour by those who are engaged in the milk-supply business.

A study has been made of the relative efficiency in maintaining low temperatures of four different types of shipping cans for cream. Unfinished cooling and sterilizing experiments are being continued in the dairy laboratory.

DIVISION OF ENTOMOLOGY.

Much of the time of the Entomological Division during the past year has been taken up in planning and starting new lines of investigations, as the new Entomologist began work on October 1 without practically any equipment or work in progress. Studies are being made largely on the life history of the harlequin bug, cabbage webworm, cabbage aphis, corn weevil, plum curculio and peach tree borer, supplemented by experiments designed to work out more successful and practical methods for their control. Early in October the Entomologist discovered on cabbage and turnips a new species of the cabbage webworm for North Carolina, it probably having been introduced into the State during the past two years.

An insect collection, representing all the injurious forms occurring in the State, with records of date and places of occurrence, is being gradually made. During the year a Bulletin treating of about forty insects has been prepared, which gives a description, life history and remedies for the control of these insects which attack the leading truck crops grown in North Carolina.

CORN SPECIAL.

The Station, in cooperation with the Norfolk and Southern Railway, operated a Corn Special train through the Eastern portion of the State. The Special started from Raleigh on March 22 and returned on April 1. While out, visits of two hours or more were made to twenty villages and towns and talks on matters pertaining to corn growing were made. The object in running this train was to try to stimulate farmers to the production of larger yields of corn per acre by impressing upon them the importance of the adoption of

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better methods of selecting seed, fertilizing, cultivating, harvesting, handling and combating the insect and disease enemies of this crop. The train consisted of two audience cars and an exhibition car, and the lectures were sometimes delivered in the audience cars, sometimes in school or court-houses, and sometimes in the open where buildings were not accessible sufficiently large to accommodate the crowd. The smallest attendance was forty, and the largest between four and five hundred, and an average of one hundred and forty-five. At four places evening meetings were held, and these were devoted to lectures on the applications of Science to Agriculture and on general agricultural and educational matters. The train was furnished and operated free by the Norfolk and Southern Railway.

In the exhibition car were carried two to four type-ears of fifty-odd varieties of corn which we have been testing comparatively in the State during six or eight years, and which the farmers have heard of but which most of them have never seen. In addition to these, seed of varieties of oats, wheat and cowpeas and samples of the leading types of soil found in the State were neatly arranged in museum jars to emphasize those salient points which it was especially desired to bring out and impress. On board were also specimens of the insects and diseases which are doing most damage to the crops and orchards of North Carolina, affected plants and seeds, and spraying mixtures and apparatus that should be used in combating them.

At each stop, as far as possible, the crops and orchards were examined and affected specimens were brought into the cars and discussed and remedies recommended. It is believed that in this way the farmers in the localities visited were impressed with the importance and practical value of the work of the Station.

BULLETINS.

Bulletins have been issued as follows:

No. 197.—Some Insect Enemies of Garden Crops, by R. I. Smith.

No. 198.—Handling and Marketing of Milk and Cream, by John Michels.

No. 199.—Feeding Experiments with Cows and Calves, by John Michels.

No. 17.—(Press Bulletin)—The Grape Black Rot, by F. L. Stevens.

The reports of the heads of the several Divisions and financial statement follow:

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REPORT OF CHEMIST.

During the past year the Chemical Division has made analyses of four hundred and eighty-six samples, of which four hundred and fifty-five related to the work in investigation and thirty-one were miscellaneous.

The miscellaneous samples consisted of:

Soils	3
Marls	3
Fertilizing materials	9
Feeding stuffs	6
Lemon oil and extract	3
Drinking water	1
Solutions for standardization	6

These thirty-one miscellaneous samples involved ninety-five determinations, as follows:

Chlorine	1
Sulphuric acid	1
Total nitrogen	24
Free ammonia	1
Albuminoid ammonia	1
Total phosphoric acid	15
Soluble phosphoric acid	8
Insoluble phosphoric acid	10
Silver	1
Potash	8
Lime	5
Moisture	3
Total solids	1
Insoluble matter	4
Volatile matter	1
Ash	1
Alkalinity	4
Acidity	1
Citral	3

The miscellaneous work was for the Divisions of Administration, Agronomy, Botany, Dairy Husbandry and Poultry Husbandry of the Station.

The four hundred and eighty-five samples, relating to the work in nitrogen, involved nine hundred and seventy-three determinations, as follows:

Ammonia by the Kjeldahl and Nessler methods	54
Ammonia by the Kjeldahl method	6
Ammonia by sodium hydroxid	68
Ammonia by magnesia	274

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Nitrites colormetrically	284
Nitrates colormetrically	4
Nitrates by the Tiemann-Schulze method	283

This work on nitrogen has occupied the greater part of the time and energies of the Chemical Division and has consisted of a study of nitrogen fixation, ammonification, nitrification and denitrification in soils and in solutions, under different conditions and with different organisms and nutrients. The details of the work will be set forth more fully in bulletin form and in the report of the Botanical Division, in cooperation with which this work is done.

Among other conclusions reached, it has been found that the organisms concerned with nitrogen metabolism do not act the same in soils and in solutions and that there is no relation between the results in these two media. This shows that the use of soils themselves for this investigation as originally planned by this Division several years ago was wise.

This Division has devised a method for getting rid of organic matter in soil extracts so that the amount of nitrates may be determined colormetrically without interference from this cause. A paper embodying the results of this work is submitted herewith for publication.

This Division is very much handicapped for lack of room, and it is to be hoped that the next General Assembly will provide a Chemical Building for the Station and College work. In the meantime more space is very desirable.

The analytical work of this Division was performed by W. A. Syme mainly, and to a small extent by A. J. Wilson, both of whom have shown commendable zeal and corresponding success in their efforts.

Very respectfully,

W. A. WITHERS,
Chemist.

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REPORT OF BIOLOGIST.

I beg to submit a report of the work of the Division under my charge for the fiscal year now closing:

INVESTIGATIONS CONCERNING APPLE DISEASES.

Work concerning apple diseases began in 1906 under the Adams fund, has been continued throughout the year.

Apple Twig Disease, which prevails in most sections of the State, has been closely studied. The fungus which causes it has been isolated and its character studied in pure culture. It proves to be a species of *Phyllosticta* or *Phoma,* which has been very destructive to fruit in Arkansas, West Virginia, and several other States. As yet the disease seems to be limited to the twigs, and has not been noted upon fruit here.

A second apple twig disease has been found in destructive abundance in many sections of the State. It proves to be a species of *Hypochnus,* which has not been recognized heretofore except in Brazil, where it was reported by Noack in 1898.

Apple Leaf Spot, which is very destructive, especially in the mountains, has been studied, and will be the subject of further investigation.

Cankers of apple and pear branches are exceedingly abundant and destructive, and scores of specimens have been received. These cankers have been studied and it has been determined that, in most instances, they are due to *Sphæropsis.* Sphæropsis canker of the apple is an old enemy, but it seems to be especially destructive here. Sphæropsis canker of the pear has not, to my knowledge, been known before. Both of these cankers, in addition to causing injury to the twig and branch, also bring about ripe rot of the fruit.

Monilia fructigena, causing rot of the apple, has been found and studied somewhat. This is the first time, to our knowledge, that this disease, which is exceedingly destructive in Europe, and which has been reported in some other parts of the United States, has been found in North Carolina.

INVESTIGATIONS CONCERNING LETTUCE SCLEROTINOSE.

Investigations of this exceedingly serious lettuce disease, begun under the Adams fund a year ago, have been continued throughout the past year. Two large cold frames for the raising of lettuce under canvas have been constructed on the Station farm, and a small crop of fall lettuce and a large crop of spring lettuce was raised for the purpose of studying the disease. Hundreds of plants were inoculated and the progress of the disease carefully noted. The fungus

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was also studied in the laboratory, receiving close attention as to the manner of infection by means of spores and mycelium; as to the life history of the fungus; number of spores formed and the condition of spore formation; action of poisons upon the fungus; its growth at normal temperatures; and other points of morphological and physiological interest. Much was learned concerning the fungus and the disease. This matter will be presented for publication in bulletin form soon. The lettuce beds, now thoroughly infected with the disease, are in excellent condition to begin a study of methods of combating the disease, using to this end the knowledge which we have gained concerning it in this year's study.

OTHER PLANT DISEASES.

Cotton Anthracnose.—Many complaints have been received from various portions of the State concerning cotton anthracnose. Some attention has been given to it in the laboratory, and some tests concerning the transmission of this disease from year to year, by seed, are under way.

A New Sweet Potato Disease.—A sweet potato disease that we are calling the "soil rot," which seems not to have been described in literature before, has been repeatedly submitted to this laboratory by sweet potato growers from various sections of the State. We have found a fungus (*Fusarium*) which is constantly associated with this disease, and which seems probably to be the cause of it. Experiments are under way to determine whether this is actually so.

An Unknown Tobacco Disease was reported to us from Hillsboro. An examination of the disease was made on the ground. Numbers of plants were dead in certain regions of the field. No cause could be assigned. Material was brought to the laboratory for further study and no fungus or parasite was found associated with this disease. If this disease should prove of permanent importance, further study will be given to it.

Corn Mold.—Samples of moldy corn have been received from about fifty farmers, and in nearly every case the mold seems to be due to a species of *Diplodia*. A report of this work on corn mold will be published soon.

Bean Anthracnose.—Material for study of seed transmission of this disease, which prevails throughout the trucking section of the State, has been secured, and a study will be made of the transmission of the disease from year to year by seed, and also of the possibility of preventing such transmission.

Cucumber Mildew.—Cucumber mildew has been very destructive in several portions of the State on both cucumbers and cantaloupes. We have planted cucumbers in our lettuce beds and will conduct spraying experiments upon them this spring.

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Pear Septoria.—In the neighborhood of Wilmington, pear trees suffering very seriously from some disease were found. Laboratory study showed this disease to be caused by a species of Septoria.

COLLECTION OF PLANT DISEASES AND FUNGI.

An effort has been made to enlarge the Station collection of all kinds of parasitic fungi, either on weeds, cultivated plants, or wild plants. Also to secure typical specimens of diseases of cultivated plants.

GERMINATION OF OAT SEED.

This has been a subject of rather extensive investigation. Oats were submitted to formalin at different strength, for various lengths of time, under various conditions, using different qualities and different varieties of oats. It was found that different varieties would withstand the action of formalin differently; that the seed of poor quality are killed to a much larger extent than are seed of better quality. It thus appears that the few seed lost in the formalin treatment are undesirable ones.

PLANT BREEDING FOR DISEASE RESISTANCE.

Watermelon Wilt.—The work of testing and selecting melons with the object of securing a variety resistant to the wilt, was continued this year. Ten varieties resulting from previous selections were tested on isolated plats on sick soil at Auburn. There was a very much larger percentage of resistance this year than last, more of the plats produced edible melons and there was a very much larger percentage of edible melons on the plats, than in previous years, nearly three-fourths of the melons in some plats being of high quality.

Twenty-nine selections of seed from melons of high resistance to the disease and of highly desirable quality were made for further tests next year.

Tobacco Wilt.—Several varieties of tobacco have been developed in our previous breeding work to such an extent that they will grow with high resistance upon infected soil on which none of the ordinary varieties of tobacco will grow at all. We now have five such varieties. With one only forty plants out of nine hundred and fifteen wilted; another fifteen out of three hundred and fifty-nine; another twenty-five out of three hundred and five. These strains of tobacco will be tested again this year.

STUDY OF SPORE MEASUREMENT.

A study of spore measurement has been made with the object of ascertaining the degree of variability existing among fungi when grown under different conditions with different nutriment, etc. Results of this work are about ready for publication.

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SOIL BACTERIOLOGY.

Nitrification.—Work on soil bacteriology under the Adams fund has been continued. Nitrifying organisms, both the nitrate makers and the nitrite makers, have been isolated, enabling us to study them in pure culture. An improvement upon various methods of technique has been made regarding the preparation of silicate jelly. An account of this was published in the *Centralblatt fur Bakteriologie, Parasitenkunde u. Infektionskrankheiten*, Volume XXI, No. 13, 1908. Very numerous tests have been made of the nitrifying power of various soils under various conditions, and a critical study has been made of the methods of determining nitrifying power of soils, and the factors which effect the nitrifying power. The relation of temperature, aeration, degree of moisture and chemical composition of the medium to nitrification has been closely considered. Careful study has been made of the behavior of nitrifying organisms when in solution and when in soil. It has been ascertained that there is a very great difference in the behavior of these organisms in the solution and in the soil. An attempt has been made to ascertain the reason for this difference.

Ammonification.—Ammonifying organisms have been studied much as have nitrifying organisms, to ascertain what proportion of soil organisms are ammonifiers, under what conditions they ammonify most rapidly, and the behavior of these organisms in soils and in solutions.

Nitrogen Fixing Bacteria.—Some attention has been given to these organisms, particularly as to their ability to fix nitrogen in soils, as compared with their ability to fix nitrogen when in solutions.

Availability of Ammoniacal Nitrogen as Compared with that of Nitrate Nitrogen.—This fundamentally important question has been made the subject of study in pot tests and in the field. It seems very probable, from other studies, that our soils are deficient in nitrifying power. If this be so, it is very important to know whether nitrogen in the form of ammonia is fully as acceptable to the plant as nitrogen in the form of nitrate. If the nitrate be for any reason better suited to plant nutrition, it then becomes important to devise some mode of increasing the nitrifying power of our soils.

LEGUME INOCULATION EXPERIMENT.

Tests are planned and are partially under way to determine whether the root tubercle organism of burr clover is capable of producing root tubercles upon alfalfa.

PTOMAINE INVESTIGATION.

Investigations have been begun to determine under what conditions poisonous products are formed in milk, and what source of con-

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tamination is most likely to produce such poisons. The work has not yet been carried to completion.

PLANT SURVEY.

This work is carried on in cooperation with the Bureau of Plant Industry. Hundreds of letters have been sent to farmers throughout the State, in order to ascertain the prevalence of certain diseases of plants, and to secure information concerning their distribution. On pages 66-82 are given the results of this work.

CORRESPONDENCE.

Numerous inquiries concerning plant diseases and other botanical questions have been received and answered. In all, about 4,000 pieces of mail matter have been sent out from this Division.

CORN TRAIN.

One member of this Division accompanied the corn train on its ten day trip to speak on "The Prevention of Plant Diseases." Approximately 3,000 farmers were in this way reached, concerning this important subject.

COMPLETED WORK.

There is now ready for publication a Bulletin on oat smut, containing the results of some six years' work on this subject. There was published, during the past year, a Press Bulletin on the Black Rot of the Grape. A technical article on the prevention of diseases of small fruits is also practically ready for publication.

I wish to acknowledge the efficient aid of J. C. Temple, Assistant in Soil Bacteriology, and J. G. Hall, Assistant in Pathology, each of whom is an exceedingly capable and well-trained man, enthusiastic and devoted to his work.

F. L. Stevens,
Biologist.

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REPORT OF POULTRYMAN.

I beg to submit the following report of the work in the Poultry Division for the year ending June 30, 1908:

For the past two seasons we have been pedigree breeding from a large number of hens in an effort to improve the laying qualities of our flock. The work done in this direction shows us that it is necessary, if we are to get the best results, to have more information about our breeders than simply how many eggs they each lay during the year, and for this reason we have for the past year been keeping records of the number of eggs laid by each hen, the fertility of the eggs, chicks hatched and the number living until four weeks old. The system that we have adopted of keeping the pedigree of the chicks will also give us the age of each chick, and this data should in a few years afford valuable information as to the best hatching season for profitable egg-production.

Work has also been commenced during the year to determine if inbreeding can be practiced for a number of years without detriment to the health and vigor of the stock, if proper attention is given to these characters in selecting stock.

There is a belief quite prevalent, especially among farmers, that inbreeding is detrimental in poultry work, or for utility poultry at any rate, and that if the practice is of any value it is only in the breeding of exhibition poultry.

It is believed that if it is an advantage for one class of breeders it may be just as useful to the others if properly used, and that many breeders are losing a great deal on account of their prejudice against this practice.

In order to test this we are breeding two different strains of Barred Plymouth Rocks, keeping each line pure, and as a check crossing the two from time to time to see if there is any advantage in the introduction of new blood.

Realizing that cottonseed meal is one of the cheapest and best stock feeds obtainable, we have undertaken some experiments to determine if it can be as successfully used in poultry feeding as in feeding other kinds of stock, and if so, in what proportion and combinations it will give the best results.

Considerable work has been done in artificial incubation, special attention being given this season to the question of whether it is beneficial to disinfect the incubator before each hatch, also whether the addition of moisture helped the hatch, either from the standpoint of the number of chicks hatched or the vitality of the chicks.

Six incubators were used in this work, all of one size and make, and machines which are sold as non-moisture machines, that is ma-

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chines that do not need any supplied moisture. Results varied considerably from one hatch to another, and it is thought best to continue this work another season, trying as far as possible to eliminate the conditions that we think were most largely responsible for the varying results from the same machines in different hatches.

It has been the almost universal custom to raise chicks that are hatched in incubators, in brooders with artificial heat, but during the past year considerable interest has been aroused in a method of raising the chicks without supplied heat, in what is known as a fireless brooder. If this system is a success it can readily be seen that it will mean quite a saving in the cost of raising chicks artificially, saving the cost of the kerosene and the time of an attendant in looking after the lamps. Information as to this system is at present time confined almost exclusively to the claims of the parties advertising the system, and it is our intention to try this system the coming season so that we can give information as to its use to parties who are interested and want information from a disinterested source.

Respectfully submitted,

J. S. JEFFREY,
Poultryman.

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REPORT OF HORTICULTURIST.

Since no experimental work had been done by the Horticultural Division for a number of years previous to my appointment, the work has of necessity been largely of a formative nature. No line of work has been carried to completion. This Division is now confining itself to the following lines of investigation:

DOUBLE FLOWER OF THE BLACKBERRY AND DEWBERRY.

This trouble, generally known as "double flower" or "double blossom" among our dewberry and blackberry growers, gets its name from the fact that there is usually a doubling of the flower. The term "rosette" would be equally applicable because of the rosette-like growth produced from the buds in spring.

The Horticulturist began studying the trouble during the summer of 1907. It was found in several sections of the State, and in each section the blackberry industry has been practically wiped out.

Experiments at Cameron.—The trouble was such a serious one that the horticulturist at once began cooperative work on a small scale with three of the leading growers at Cameron, N. C. This was to determine the nature of the abnormality, to get the growers interested, and to get the work started, since it would require at least one year before the work could be undertaken at the Experiment Station. The experiment is being conducted as follows in each field:

Four typical adjacent rows were selected in each field. The entire growth, both old and new canes, of two rows, was entirely destroyed early in July immediately after the picking season. These plants must produce sufficient new cane growth during the remainder of the season for the following year. Only the old growth (fruiting canes) was cut out of the other two rows, leaving the young cane growth made during the spring to produce the next year's crop.

This was done to determine what influence the different methods of destroying the old growth will have on the "double flower," and second, whether it is necessary to go to the heavy expense of destroying all of the cane growth, and then fertilizing heavily to produce the second growth of new canes the same season. The plants have been carefully studied since the work was started and valuable data have been obtained. Photographic records are being made of the development of the normal and abnormal buds and growth. While valuable data have already been obtained, the most important data during this season will be obtained during the fall months. Furthermore, it will require further study and experimentation before conclusive statements can be made regarding the cause and best method of controlling the trouble.

Experiments at Station Farm.—Extensive experiments with "double flower" are now being conducted on the Station farm. Six

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plots of Wilson blackberry and six plots of Lucretia dewberry, each plot consisting of three rows, are being devoted to this work. These plots were planted during January of the present year. These particular varieties were selected because they have been the most important, commercially, in the State and are badly affected. It will require one season to get the plants well established before any real experimental work can be undertaken. Each plot will then be treated differently in the way of pruning and destroying the old and young canes to see what effect it will have on the "double flower."

Aside from this, we are testing twenty-two other varieties of blackberries and fourteen of dewberries to determine what varieties are affected.

SELF-STERILITY OF DEWBERRIES AND BLACKBERRIES.

Many of our varieties of dewberries and blackberries give unsatisfactory results when planted by themselves. This appears to be due in many cases to self-sterility.

We are now testing fifteen varieties of dewberries and twenty-three of blackberries to determine to what extent they are self-sterile; the cause of this self-sterility, and the varieties that will be the best to use for the pollination of self-sterile varieties.

Since these plants were just planted during the past winter, no data can be obtained until they come into bearing next year.

CONTROLLING ANTHRACNOSE BY CULTURAL MEANS.

The Horticulturist is now carrying on cooperative work with five of the leading dewberry growers to determine the best cultural means of controlling this disease. It is the most serious disease with which dewberry growers have to contend at the present time.

The present methods of controlling the disease are very costly. I believe that this cost can be considerably reduced by improving and modifying the present cultural methods.

These experiments are to determine how often the canes should be cut off; the best depth to cut them, and the best tools for this purpose.

The work was started last summer and accurate records have been kept of the rate and character of new growth. This year records will be kept of the amount of fruit yielded by each plot.

MISCELLANEOUS WORK.

The Division is giving considerable study to several of our leading fruits. Photographs are being made and notes taken on the various methods of propagation, planting, cultivation, and marketing of the more important fruits. The Division has made a fairly complete survey of the dewberry industry of the State, including localities, names and addresses of growers, and acreage. A similar survey of other leading fruits is now well under way.

Respectfully submitted,

F. C. REIMER,
Horticulturist.

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REPORT OF ANIMAL HUSBANDMAN.

I beg to submit the following report of the operations of this Division for the year just closed:

It will be necessary to say at the outset that the brief report following is simply a general status of the work now in progress by this Division. No line of work has been fully completed during the past year, owing to the fact that it was necessary to provide entirely new equipment on the Station farm.

The first line of work undertaken was a determination of the amount of fermented cottonseed meal which could be fed safely in conjunction with corn to young and growing hogs; to determine the economy of gain; and the quality of the product when compared with corn alone, and corn and linseed meal.

The length of the feeding period was six months. The check lot of pigs fed on corn remained in an unthrifty condition all during the experiment. The two lots of pigs fed on corn and cottonseed meal in varying proportions made larger gains as the amount of cottonseed meal was increased. This was true, however, only during the first period of three months. The lot which made the largest gain received the most cottonseed meal, though none of the pigs were fed more than .62 pound per day. The gains made were clearly in favor of the ration composed of four parts of corn and one part of cottonseed meal. The limit of profitable feeding was three months or thereabouts. During the last three months of the feeding period the gains were materially decreased with all pigs fed cottonseed meal, which would seem to indicate that this material should not be fed longer than seventy-five to ninety days. If fed to hogs, great care should be taken to measure or weigh the amount fed each time, and discontinue feeding after the time stated. While it is possible that the feeding period could be lengthened, it would not seem to be a safe venture for the farmer to make.

A second line of work was undertaken to determine the relation between feeding hogs in dry lots and on forage crops. The ration for each lot consisted of three parts of corn and one part of fermented cottonseed meal. With three lots, this ration was fed in conjunction with green crops; with the fourth lot, the corn and cottonseed meal were fed alone in the same proportion in a dry lot. This experiment is now nearly completed, and bids fair to give valuable data in favor of the green crops, which can be produced so abundantly by North Carolina farmers. The first grazing crop furnished was fall rye, after which oats and Canada peas; oats and rape were given as a second series in the succession. For the third series of forage crops, cowpeas and corn, cowpeas and sorghum, sweet potatoes and peanuts were fed. These crops all made rapid growth and furnished feed for the greater part of the summer and fall months.

This is one line of work which the Station expects to thoroughly

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investigate, as swine raising is one of the paying lines of work for the farmers in this State. The pigs in this experiment are all thrifty and will be ready for market by the latter part of December, after which the results of the experiment will be reported in detail.

The third line of work undertaken was the feeding of cottonseed meal to horses and mules to determine:

1. The possibility of using such a supplementary feed with corn.
2. The economy of the ration.
3. The amounts and condition in which it could be most satisfactorily fed.
4. The effect on the condition of the animal.

The work mules of the Station are being used in this experiment, and each mule will receive one of the rations fed each of the other mules during the experiment.

The preliminary period of the experiment, lasting from April 6 to May 20, proved conclusively that the meal was relished by the mules in quantities as large as one pound, and in some cases one and one-half pounds per day. The meal was mixed with ear-corn for two mules, and with corn and cob-meal for three mules during the first part of the final feeding period. The final ration which is being fed at the present time, is composed of ear-corn and cottonseed meal, the meal fed ranging from three-fourths of one pound to two and one-fourth pounds per day.

The above experiment is to be run one year exclusive of the preliminary period. The ration will be reversed at the end of every two months to eliminate individuality. During the first part of the experiment the same amount of meal was substituted for the corn that was taken out of the ration. At present, however, one pound of cottonseed meal is being substituted for as much as two pounds of corn, to determine the efficiency of the cottonseed meal in furnishing protein, in replacing the corn and balancing the ration.

Most farmers are feeding an all-corn ration, which is very expensive and undesirable, to say the least. The purpose of this experiment has been to work out a cheaper, practical and more efficient ration.

In addition to the above work, there has been considerable improvement made at the Station farm in the way of buildings and lots. A number of farrowing pens have been built, feeding floors, pens and hog pastures.

The Station has also purchased several high grade Poland China brood sows and a pure bred boar, which are to be used for raising hogs of uniform type for future experimental work.

Considerable correspondence has been carried on, this being mostly in reference to breeds of live stock best adapted to the conditions of the State; questions in regard to breeding, feeding and management of live stock; and the laying out lots for pasture purposes.

R. S. CURTIS,
Animal Husbandman.

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REPORT OF DAIRY HUSBANDMAN.

The data obtained on the relationship of cold to the keeping quality of milk prove conclusively that it is feasible for dairymen to deliver their morning's milk in the afternoon and the night's milk the following morning, thus making the milking independent of delivery. Indeed they prove that sweet milk may be furnished by making only one delivery a day. The data, therefore, point the way to saving a great deal of labor as well as much unnecessary drudgery.

The feeding experiments showing that rolled oats may be gradually substituted for milk in calf rearing, are of far-reaching importance in that the reduced cost resulting from such substitution will undoubtedly be a strong factor in inducing dairymen to raise enough calves to build up and replenish their herds.

In the stover and hull experiments conducted by this Division, the fact is brought out that dairymen will save thousands of dollars annually by raising and feeding corn stover instead of buying and feeding cottonseed hulls.

In another experiment, it was demonstrated that dried brewers' grains have the same feeding value as corn meal when both are used to supplement a grain ration consisting of one-half cottonseed meal and one-quarter corn meal. Since the dried brewers' grains can usually be purchased at a much lower price than corn meal, the economy of using them is evident.

The original plans presented for the construction of cheap ice boxes and sterilizers will, if adopted generally, save thousands of dollars to our dairymen, besides resulting in more efficient cooling and sterilizing than would be possible without them.

The Division has also worked out a new method for making cottage cheese, which is especially adapted for making this cheese on a commercial scale.

Cottage cheese has been made for centuries, but this is the first time, so far as known to the writer, that any successful effort has been made to place the making of this cheese upon a commercial and scientific basis. The method of manufacture, as well as the method of marketing, as worked out by us, insures absolute uniformity of product, and makes it possible to manufacture cottage cheese on as large scale as is done with many other kinds of cheese.

This new method opens the way for an extensive and profitable use of skim milk.

Respectfully submitted,

JOHN MICHELS,
Dairy Husbandman.

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REPORT OF ENTOMOLOGIST.

When I came to the Station on the first of last October, I found the Entomological Division practically without laboratory, library and office equipment. Some little time was required to get things in shape before any investigational work could be taken up. The insect collection was found to be small, poorly arranged and contained few of the more common species. My time, therefore, for the past nine months, has been devoted largely to making insect collections—both by collecting and by breeding—to attending to correspondence, and to getting under way new lines of investigation.

PUBLICATIONS.

A Bulletin, entitled "Insects Injurious to Garden Crops," which contains sixty-four pages, has been prepared. This was written with especial reference to the needs of gardeners, truckers and farmers in North Carolina.

INVESTIGATIONS.

Life history studies, and in some instances experiments with remedial measures, have been conducted with insects as follows:

Harlequin Bug (*Murgantia histrionica*).—Commencing when the bugs first appeared this spring, careful observations and notes were made to determine the following points:

(1) Egg laying record; (2) period of incubation of eggs; (3) length of life cycle; (4) number of generations; (5) parasitism of eggs and nymphs; and (6) general habits.

Various direct remedies have been tested and the kerosene emulsion treatment of fifteen per cent strength has proved quite effective against young and half-grown bugs, while it also prevents some of the eggs from hatching. The egg-laying record of the hibernating brood has been secured, one female laying one hundred and seventy-nine eggs between April 7 and June 9. Other individuals under observation laid from ninety-six to one hundred and twenty eggs during a shorter period. Many interesting and important facts about terrapin bugs have been noted, but this line of investigation is yet in progress.

Cabbage Web-worm (*Hellula undalis*).—Plans were made this spring to study the life history of this insect, which was first discovered in North Carolina by the writer during the past October. Up to June 30 no web-worms have put in their appearance, but it is expected they will be present certainly by late summer or early fall.

Cabbage Aphis (*Aphis brassicæ*).—Gratifying results have been secured from the use of a spray of common soap solution as a remedy against the cabbage aphis. During the year tests have been made

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both on the College and Central Hospital farms, using various soap solutions of different concentrations in comparison with ten and fifteen per cent kerosene emulsion and tobacco decoctions, with the results indicating the superiority of common soap solution, both in efficiency and economy.

Plum Curculio (*Conotrachelus nenuphar*).—This insect was made the subject of a life history study during the spring and the length of egg, larva and pupa stages were determined for North Carolina conditions. A common species of parasite (*Sigalphus curculionis*) was reared in considerable numbers from the curculio larvæ. Observations on the egg-laying and feeding habits were made and recorded. The scope of this experiment is also to be increased, and it is to be continued during the coming year.

Fumigation Against Corn Weevils.—Because of numerous complaints of poor results coming from the use of carbon bisulphid as a remedy against corn weevils, the writer has undertaken to find some other substance or substances that will be cheap and effective. A number of tests were made during February and March, but the results, while encouraging, indicate that much further work of an enlarged nature should be carried on before attempting to draw definite conclusions. Extended work is planned to be taken up in a vigorous manner during the coming year.

Respectfully submitted,

R. I. Smith,
Entomologist.

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NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATIONS, 1907-1908.

DR.

To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ending June 30, 1908, under Acts of Congress, approved March 2, 1887, and March 16, 1906:

Hatch Fund	$15,000.00
Adams Fund	9,000.00

CR.

	Hatch Fund.	*Adams Fund.*
By Salaries	$6,945.83	$6,780.00
Labor	2,624.90	508.57
Publications	938.54	.....
Postage and stationery	434.98	.....
Freight and express	258.59	.....
Heat, light, water and power	58.79	.....
Chemical supplies	36.81	406.94
Seeds, plants and sundry supplies	445.97	367.91
Fertilizers	218.10	308.77
Feeding stuffs	733.04	.....
Library	109.00	143.29
Tools, implements and machinery	350.86	.....
Furniture and fixtures	566.30	.....
Scientific apparatus	1.23	162.05
Live stock	457.00	200.00
Traveling expenses	467.05	122.47
Contingent expenses	15.00	.....
Buildings and land	338.01	.....
Total	$15,000.00	$9,000.00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1908; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $24,000, and the corresponding disbursements $24,000; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress, approved March 2, 1887, and March 16, 1906.

(Signed)

J. T. ELLINGTON,
O. L. CLARK,
T. T. BALLENGER,
R. H. RICKS,
Auditors.

(Seal.)

Attest: A. F. BOWEN, *Custodian.*

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SCIENTIFIC PAPERS.

EXPERIMENTS UPON THE EFFECT OF FORMALIN UPON THE GERMINATION OF OATS.

By F. L. STEVENS.

Many different strengths of formalin are or have been at various times recommended for the prevention of oat smut; also many different modes of application and different lengths of exposure to the formalin fumes.

The two factors which must control in the selection of the strength to be employed, and the time and the mode of application, are the fatality to the smut spores and the effect upon the germination of the grain.

While the strength of one ounce to one gallon of water is employed by many with success, it occasionally results in a loss of the crop, due to its killing the seed; therefore this strength is to be regarded as within the danger limit, and is not to be recommended.

In order to ascertain whether one ounce to two gallons of water is dangerous to seed, tests were made during May, 1905, with one hundred seeds, employing three different strengths of formalin, as indicated in the following table, and with the fertilizer in one case put in the drill, in the other well mixed with the soil, and in the third using no fertilizer:

TABLE I.—SHOWING THE EFFECT UPON GERMINATION OF FORMALIN SOLUTIONS OF DIFFERENT CONCENTRATIONS.

	One Ounce Formalin to One Gallon.	One Ounce Formalin to Two Gallons.	One Ounce Formalin to Three Gallons.	Average.	No Formalin.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
No fertilizer	38.5	80.5	37.5	52.2	38 0
With fertilizer mixed with soil	63.	60.5	67.5	63.7	----------
With fertilizer unmixed with soil	68.5	57.5	53.5	59.8	100.0
Average	56.7	66.2	52.8	58.7	69.0

The results are so irregular and discordant that no conclusion seems justified unless it be that in such tests a much larger number of seeds should be used to give more reliable averages. The test was therefore modified and repeated on a larger scale in June, 1905. In each instance one pint of seed was treated with the formalin solu-

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tion at the rate of one gallon of solution to one bushel of seed. After treatment two hundred seeds were taken for the germination test, with the following results:

TABLE II.—SHOWING EFFECT UPON GERMINATION OF FORMALIN SOLUTIONS OF DIFFERENT CONCENTRATIONS.

	One Ounce Formalin to One-half Gallon.	One Ounce Formalin to One Gallon.	One Ounce Formalin to Two Gallons.	One Ounce Formalin to Three Gallons.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Cloth-covered 12 hours after treatment then planted immediately	25	95	97	93
Planted immediately after treatment	47	90	88	89
Dried 48 hours after treatment before planting	43	96	98	94
Cloth-covered 12 hours then dried with lime before planting	35	94	94	96
Average	37	96	94	93

It comes out clearly from this experiment that the strongest solution injures germination seriously, though no injury is apparent from the treatment by the other solutions under any of these conditions. There is even an indication of increased germination with the increase of the formalin, as shown by the averages, 93, 94 and 96 per cent. Whether such stimulation is a fact or whether the differences shown in the table are due to accidental variation in the seeds it is impossible to say. There is no significant difference resulting from the modes of treatment with any of the strengths unless it be with the strongest solution, which showed greatest fatality when covered 12 hours and when planted immediately. This is to be expected, since both of these modes of treatment tend to retain the formalin fumes in contact with the seed for a longer time than do the other treatments.

The solution of one ounce of formalin to one gallon of water did no appreciable injury to these seeds with any of the modes of treatment followed. In field practice, however, this solution and even weaker solutions are known under some conditions to deplete the stand. It seemed, therefore, that some other factor must at times enter into the question; that probably there is a difference between different varieties of oats or between oats of the same variety under different conditions. A more extensive experiment was therefore planned to test the following points:

Do different varieties of oats offer different degrees of resistance to formalin? What percentage of the seed is killed by formalin of the strengths usually employed? Does formalin have any stimulating effect upon germination? Are seeds of inferior quality more

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susceptible than those of medium or excellent quality? Does the fatality increase with the increase of the time of application? While many tests have been made bearing upon these points, they have usually been made with one or two factors only in mind, and the results are neither concordant nor conclusive.[1]

A series of crucial experiments was planned with the hope of gaining conclusive answers to these questions.[2]

In all cases 1,000 seeds of average quality were taken and treated for twelve hours. They were treated with formalin of the strength indicated, employing 1 cc. of the solution to 9.3 cc. of seeds, this being equivalent to the usual practice of using one gallon of liquid to one bushel of seed. The seed, after being thoroughly wetted by the solution, were placed in glass capsules, of suitable size, to prevent loss of formalin by evaporation. Great care was taken to have the lots exactly alike, except as regards the factor under observation. After treatment the seeds were planted in flats in clean sifted sand in rows one-half an inch apart, with the seeds evenly distributed in the rows. In this manner, it was possible to account for every seed. The final record of germination was taken two weeks after planting, since experience showed that all viable seeds germinated in that time.

All seeds designated as of average quality were gotten by discarding from a clean commercial sample of considerable size, all foreign seeds and empty chaff, but retaining all actual oat seeds, each of which, in case of any possible doubt, was inspected as to its integrity. This sample was thoroughly mixed and the 1,000 seeds for the test were taken absolutely without selection by always taking the seed lying nearest at hand, be it large or small. The strengths most used in practice, .26 per cent, .39 per cent, and .78 per cent of formalin, or as more commonly designated, one ounce to three gallons, one ounce to two gallons, and one ounce to one gallon, were employed; also a weaker solution, one ounce to four gallons (.2 per cent formalin). The first of these is mostly used, the second often, and the third rarely.

[1] A summary of much that has been done is presented by G. Kock Uber die Bedeutung des Formaldehyds als, Pflanzenschutzmittel U. S. V. Zeit. f. Land—Versuchswesen, Oest—. Jahr IX 1906 811.

[2] In carrying out these tests I am indebted to the efficient assistance of F. H. Brown.

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INFLUENCE OF DIFFERENT STRENGTHS UPON WHITE SPRING, RED RUST PROOF, VIRGINIA WINTER GRAY, APPLER, BURT, BLACK SPRING OAT OF AVERAGE QUALITY TREATED TWELVE HOURS.

TABLE III.—TEST OF THE WHITE SPRING OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
11	Control	998	99.8	
14	One ounce to four gallons [1]	996	99.6	—.2
15	One ounce to three gallons [2]	993	99.3	—.5
13	One ounce to two gallons [3]	985	98.5	—1.3
12	One ounce to one gallon [4]	941	94.1	—5.7

[1] .2 per cent formalin, .08 per cent formaldehyde.
[2] .26 per cent formalin, .104 per cent formaldehyde.
[3] .39 per cent formalin, .156 per cent formaldehyde.
[4] .78 per cent formalin, .312 per cent formaldehyde.

TABLE IV.—TEST OF RED RUST PROOF OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
16	Control	989	98.9	
17	One ounce to four gallons	984	98.4	—.5
20	One ounce to three gallons	984	98.4	—.5
19	One ounce to two gallons	973	97.3	—1.6
18	One ounce to one gallon	925	92.5	—6.4

TABLE V.—TEST OF VIRGINIA GRAY OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
30	Control	895	89.5	
29	One ounce to four gallons	883	88.3	—.2
28	One ounce to three gallons	855	85.5	—.4
27	One ounce to two gallons	821	82.1	—7.4
26	One ounce to one gallon	790	79.0	—10.5

TABLE VI.—TEST OF APPLER OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
10	Control	966	96.6	
8	One ounce to four gallons	977	97.7	+1.1
9	One ounce to three gallons	958	95.8	—.8
7	One ounce to two gallons	933	93.3	—3.3
6	One ounce to one gallon	912	91.2	—5.4

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TABLE VII.—TEST OF BURT OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
1	Control	908	90.8	
2	One ounce to four gallons	922	92.2	+1.9
3	One ounce to three gallons	930	93.0	+2.7
4	One ounce to two gallons	901	90.1	—.2
5	One ounce to one gallon	730	73.0	—17.3

TABLE VIII.—TEST OF THE BLACK SPRING OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
25	Control	934	93.4	
24	One ounce to four gallons	959	95.9	+2.5
23	One ounce to three gallons	949	94.9	+1.5
22	One ounce to two gallons	903	90.3	—3.1
21	One ounce to one gallon	911	91.1	—2.3

It will be noted that the White Spring, Red Rust Proof and Virginia Gray oats give perfectly consistent results, showing increasing fatality with an increase in the strength of the solution employed, the loss ranging from .2 to 5.7 per cent with the White Spring oat and from .2 to 10.5 per cent with the Virginia Gray oat.

The Appler, Burt and Black Spring oats show with the weaker of the two weakest strengths slight evidences of stimulation and an increased germination over that obtained without treatment, this varying from 1.1 per cent with the Appler to 2.5 per cent with the Black Spring oat.

Increase in fatality with increase in strength is shown with the two stronger solutions in Tables VI and VII.

The Burt oat with a loss of 17.3 per cent in germinating power, being the one when the strongest solution is considered, showing greater susceptibility than any other tested.

In Table VIII the Black Spring oat presents some inconsistencies, notwithstanding the large number of seeds used and the carefulness of the test. These may be explained, however, by the very high resistance of this oat to all strengths of solutions, thus reducing the total of fatalities to such a small number as to unduly magnify error from accidents. The high resistance offered by this oat is probably attributable to its smooth, shiny, black, hard glumes of extraordinary thickness.

It may be concluded from this series that formalin of the strength of one ounce to four gallons or one ounce to three gallons of water may be used without detriment to germination of these varieties, but

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that greater strength will appreciably injure the germinating power of some of them, and that the stimulating effect, if any, is insignificant.

TEST OF DIFFERENT TIME OF EXPOSURE TO FOMALIN AND OF THE USE OF LIME.

TABLE IX.—APPLER OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Time Treated.	Number Germinated.	Per Cent Germinated.
10	Control		966	96.6
49	One ounce to one gallon	2—10[1]	955	95.5
31	One ounce to one gallon	2 hours	984	98.4
41	One ounce to one gallon	6 "	911	91.1
6	One ounce to one gallon	12 "	912	91.2
35	One ounce to one gallon	24 "	898	89.8

[1] Formalin two hours, lime ten hours.

Table IX indicates a gradual increase in fatality with increase of the time of application, and shows slightly beneficial effect from the use of lime. Comparison of Tables IX and XI brings out the fact that the one ounce to one gallon solution may be used for two hours with greater safety than the one ounce to two gallon solution for twelve hours, and that with lime the one ounce to one gallon solution for two hours is no more injurious than the one ounce to four gallons solution for twelve hours. While no experimental evidence is at hand regarding the resistance offered by the smut spores to these solutions of different strengths for different times, it is probable that owing to the minuteness of the spores the strong solutions for the short time would be more often fatal to them than would a weaker solution for a longer time. It is probable, therefore, that in practice it will be found best to increase the strength of the solution and to use lime, rather than to increase the time.

EFFECT OF QUALITY OF SEED ON RESISTANCE TO FORMALIN.

TABLE X.—APPLER OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Quality of Seed.	Number Germinated.	Per Cent Germinated.	Per Cent Loss Due to Treatment.
10	Control	Average	966	96.6	5.4
6	One ounce to one gallon	Average	912	91.2	
45	Control	Good	991	99.1	3.7
46	One ounce to one gallon	Good	954	95.4	
43	Control	Medium	976	97.6	4.6
47	One ounce to one gallon	Medium	920	92.0	
44	Control	Poor	937	93.7	15.7
48	One ounce to one gallon	Poor	780	78.0	

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TABLE XI.—VIRGINIA GRAY OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Quality of Seed.	Number Germinated.	Per Cent Germinated.	Per Cent Loss Due to Treatment.
30	Control	Average	895	89.5	10.5
26	One ounce to one gallon	Average	790	79.0	
36	Control	Good	924	92.4	9.8
32	One ounce to one gallon	Good	826	82.6	
37	Control	Medium	909	90.9	10.8
33	One ounce to one gallon	Medium	801	80.1	
38	Control	Poor	859	85.9	20.
34	One ounce to one gallon	Poor	659	65.9	

Seeds such as were used in the preceding tests were carefully graded into three classes, each seed being examined individually. The largest, plumpest grains were designated as "good," the next lower class as "medium," and the smaller shrunken ones as "poor." Especial care was taken that no empty glumes, but only actual seeds, be included in this last class. With the Appler oat, Table X, it is seen that in the controls the seeds germinated according to quality, 99.1, 97.6, 93.7 per cent respectively, and that when treated with formalin, one ounce to one gallon, the loss of germinating power was little with the good seeds, a trifle more with the medium seeds, but very great with the poor seeds. The average has little or no significance, since no record was kept of the percentage of seed of each quality in the average sample.

With the Virginia Gray Oat, Table XI, less concordant results were secured. The main fact, however, comes out clearly that there is much greater fatality from treatment among the poor than among the better seed.

The fact brought out in these two last tables is very significant, in that it shows that even the slight diminution in germinating power, resulting from the formalin treatment of oats, is of benefit in that it is in effect a form of seed selection resulting in a partial elimination of the poorest seed, to the betterment of the sowing. It is probably to this fact, in part at least, that we may attribute the beneficial effects of the formalin treatment, so frequently noted, even when no smut appears in control plats.

In view of these facts, it may be desirable in practice to use the strongest solution employed in these experiments, or even stronger, as a means of culling out the poor seed, to then test the germinating power in order to ascertain the loss of live seed, and to regulate accordingly the amount of seed to use per acre for sowing. Mechanical separation might, however, attain more economically the same end.

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A STUDY OF CORN MOLD.

By F. L. STEVENS and J. G. HALL.

The disease of corn known throughout the State as "mold," "mildew," "rot," "souring," attracted particular attention in 1906, and study of the disease was begun at that time.

The disease affects the ear, manifesting itself as a whitish growth of mold over the surface of the grains, sometimes affecting the whole ear and at other times portions only of it. The amount of fungus visible upon the superficial parts of the grain is not large, but upon breaking open the ear, it is found that the spaces between the bases of the kernels are often densely packed with masses of pure white mycelium.

Externally, no signs of fruiting bodies of any kind are apparent, but close examination at the point of attachment of the grains to the cob, in many instances, reveals the presence of exceedingly minute black specks, which under the microscope prove to be the fruiting organs (pycnidia) of the fungus.

Numerous mail inquiries have been received concerning this disease, and in response to letters, a large number of specimens, representing many different sections of the State, were received and examined. While other fungi were occasionally present, in nearly every instance the symptoms given above were predominant, and the fungus with the white mycelium and the black pycnidia was the only one that was noticed in constant association with the disease.

The pycnidia, upon examination under a microscope, were seen to be filled with rather long, slender, smoky, usually two-celled, occasionally three-celled, spores. These spores were slightly thicker at one end than at the other, and were darker in color at the thicker end than at the narrow end.

This fungus was readily isolated in culture by means of agar plates, and it has been under cultivation in the laboratory for nearly two years. It grows rapidly, producing abundant loose, floccose, aerial mycelium, and a sparse sprinkling of the characteristic pycnidia with its characteristic spores.

While longer in proportion to the thickness than is usual in the genus *Diplodia*, this fungus must be regarded as a *Diplodia;* in its relationship, however, verging toward the genera *Septoria* and *Hendersonia*, particularly toward the dark spored, short-spored septoria, such as *Septoria piricola* Desm., which grows upon the pear.

Three species of *Diplodia* have been described upon *Zea:* 1, D. *Maydis* (Berk.) Sacc. Syll. Fung. III 373; 2, D. *Frumenti* E. & E. Syll. Fung. X 292; 3, D. *Macrospora* Earle Syll. Fung. XIV 939.

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These were originally described as growing upon stems and probably were saprophytic.

The species which we mention above agrees well with the description of *Diplodia Macrospora* Earle, and is without question to be regarded as *Diplodia Macrospora,* although that species has not heretofore been reported as occurring upon the ears of corn.

A second species of *Diplodia* was also found in some instances on the molding ears, evidently as a cause of the mold. This species, while to the naked eye showing no difference from *Diplodia Macrospora* as to its mycelium or pycnidia, was markedly different in shape and size of its spores, which were regularly linear-oval, evenly colored throughout and much shorter than the spores of the *Diplodia Macrospora.* This latter species agrees completely with the description of the *Diplodia Maydis* and is to be regarded as that species.

The latter species has recently been the subject of investigation in Illinois,[1] and was also reported upon at the last meeting of the American Association for the Advancement of Science.[2]

It is estimated that in 1906, the year in which there was the greatest amount of dry rot, so far as any records have been made, the loss was 4.5 per cent of the entire crop in Illinois. This represents a loss of over 15,000,000 bushels, having a value of more than $5,000,000. The loss in 1907 was less than 2 per cent of the crop or about $2,000,000.

In order to glean from the farmers as many facts as possible concerning this disease, several hundred letters were sent out to leading corn growers throughout the State, asking the following questions:

1. Under what conditions of weather does it do most damage, during wet seasons or dry seasons?
2. Is it most damaging in corn standing alone on the stalk or in corn which is put up in the shock?
3. Does it appear before the corn is husked or after?
4. If it shows before husking, does it continue to develop after husking?
5. Is there any particular variety which is more susceptible than other varieties?
6. Does the time of ripening of corn affect the rotting?
7. Estimate the amount of damage as follows:

a. Dollars per acre.
b. Per cent of crop.
c. Damage in your county.

In response to these letters we select for analysis twenty-four replies, representing the twenty-three separate counties, Jackson, Mitchell, Ashe, Madison, Caswell, Halifax, Henderson, Pasquotank, Gas-

[1] Ill. Agricultural Experiment Station Circular 117.
[2] Science N. S. XVII, No. 684, p. 212. Dry Rot of Corn and its Causes. James T. Barrett.

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ton, Stokes, Sampson, Burke, Forsyth, Northampton, Yancey, Davie, Wilson, Watauga, Buncombe, Macon, Chatham, Catawba and Alamance. In ten instances, these replies were accompanied by samples of diseased corn, which proved to be unquestionably the disease under consideration. While no certainty exists that the other fourteen replies relate to this disease, it is most highly probable that they do, since the disease was carefully described, since there appears to be no hesitation on the part of the farmer as to his recognition of it, and since in the ten instances where samples were submitted, no error was noticed.

As to the first question: there was an unanimity of opinion that the disease was worse in wet seasons than in dry ones. In one instance, the reply was that it was that it was worse in warm, wet weather.

As to the effect of shocking: three replies stated that there was no difference whether the corn was in shock or still standing, six replied that the disease was worse in the shock, and six replied that the disease was worse when it was not in shock, so that in all probability the disease is independent of this condition.

Regarding question number three: fifteen stated that the disease appears before the corn is shucked, while only two stated that the disease comes upon the corn after shucking. One stated that it continues to develop after shucking, eighteen state that it does not.

As to specially susceptible varieties: eleven replies were to the effect that some varieties were more subject to the disease than others. Three replies stated that there was no difference in susceptibility in the varieties. Among the varieties named as being more susceptible than others were the following:

Any early varieties, Iowa Silver Mine, Boone County White, Hickory King, Any red variety, Large Cob, Dent, Strawberry Corn, Sugar Corn, Soft Varieties, Yellow, Large Cob, Large Kernel.

The amount of damage was placed at from 10 to 50 to 75 per cent of the value of the crop. Estimates as to dollars per acre and the damage per county were so unsatisfactory as to be undeserving of analysis. It is certain, however, that the disease causes, in the aggregate, a very large loss in this State. Both species of *Diplodia* causing this mold are known to live and flourish upon corn stalks, and it is not to be doubted that the fungus multiplies on old stalks, making there enormous quantities of spores, which, spread by the wind, cause disease to the following crop. It is therefore very important to plow under, so far as is possible, all old stalks, leaves and shucks, to thus diminish the amount of infected material.

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I. STUDIES IN SOIL BACTERIOLOGY.[1]

NITRIFICATION IN SOILS AND IN SOLUTIONS.

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Following the lead of Robert Koch in 1881, in the utilization of his gelatine plate method for enumeration of the bacterial flora of various soils, came a vast number of researches directed toward a determination of the numbers of bacteria in soils from various sources, depths, conditions, etc., and much valuable information was gained as to the relative numbers of organisms obtaining in soils under different conditions. But it came to be recognized after a few years that the method of enumeration of bacterial floras by plate counts falls far short of furnishing the needed data for a proper understanding of the functions of bacteria in soils.

Attention was then directed toward methods, not to determine the *number of bacteria* in soils, but to determine the abundance or efficiency of the particular kinds of organisms that are known to be either beneficial or injurious to agricultural soils. This problem was essayed in two different ways, by Remy in 1902,[2] and Hiltner and Störmer in 1903.[3]

The method of Remy consists in using as an inoculum, weighed amounts, usually one to ten grams, of the soil under investigation, and with this inoculating sterile solutions of various composition to ascertain the chemical changes effected in the solutions by the bacteria introduced with the inoculum. In this way, for example, a 1 per cent peptone solution is inoculated, and the amount of ammonia found at the end of a given number of days is taken as an indication of the ammonifying power of the soil. Similarly, solutions containing ammoniacal compounds are employed to gain an index of the nitrifying power, and Giltay's solution is used to measure the denitifying power.

The method of Hiltner and Störmer consists in using solutions similar to those employed in Remy's method, but making in each analysis a series of inoculations with the inoculum varying from 1000 milligrams to 0.001 milligram of soil. Since, in some instances, the dilution used fails to cause reaction because the quantity of inoculum is so small as to contain none of the specific organisms

[1] The facts set forth in this article were presented in substantially this same form at the seventh annual meeting of the North Carolina Academy of Science May 2, 1908. See Science 27 pg. 988. This article also appears in the current volume of the Centralblatt für Bakteriologie II ab.

[2] Centr. Bakt. 2 Abt. 8 (1908) pp. 657-699, 728-761.

[3] Studien uber die Bakterienflora des Ackerbodens, Berlin, (1903).

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in question, while in other instances there is reaction, indicating the presence of the organism, some conclusions are permissible as to the number of bacteria present of the particular kind in question in the inoculum used.

The methods of Remy and of Hiltner and Störmer and modifications of these, have been used in numerous investigations in soil bacteriology, and much knowledge has been gained as to the abilities of the bacteria of the soil to effect changes of particular kinds in the solutions employed and under the conditions of the tests.

The use of soil itself as a culture medium in which to study the activities of bacteria under conditions of bacteriological control seems to have been singularly neglected, and when employed, has been used only for special purposes, e. g., Coleman[1] and Bazarewski,[2] who employed soil in physiological studies of nitrifying organisms, and by Wimmer[3] and Hoffman.[4]

The object of soil bacteriology is to picture clearly the kinds and intensities of bacterial activity in the soil in order that the effects of cultural methods, fertilizers, crops, etc., upon the bacterial flora and its efficiency may be known, to the end that defects may be recognized and corrective measures employed.

That the methods of Remy, of Hiltner and Störmer and of their followers come much nearer to this ideal than mere colony enumeration, can not be doubted, but that either of these methods very closely approximates actual occurrences in the soil itself is questionable. Conditions of bacterial life in solution and in soil may be, indeed they certainly are, fundamentally different, and the most that can be said with assurance, when isolated species or natural or artificial composites of species, are inoculated into solutions of known composition and produce certain chemical changes, is that the organisms present bring about the changes noted under the conditions of the test, *i. e.*, dealing with solutions of the artificial nature of those that are employed.

By such tests it has been noted that certain species of bacteria and certain live soils when placed in solution bring about nitrification, ammonification, denitrification, etc., with certain degrees of intensity. It by no means follows of necessity that the same organisms when in soils cause the same chemical changes, or if so, with the same intensities.

To picture adequately the functioning of soil bacteria, methods must be used which show as nearly as possible the effects as they are actually produced by bacteria in soils. To assume that bacterial

[1] Untersuchungen ueber Nitrifikation Cent f. Bak. 2 abt. 20, 401, (1908).
[2] Beitrage zur Kenntnis der Nitrifikation und Denitrifikation im Boden 1906. Diss. Göttingen.
[3] Zeit. f. Hyg. 48, 160 (1904).
[4] Relation of Soil Bacteria to Nitrogenous Decomposition, 23rd Rept. Wis. Agr. Exp. St. (1906) 120.

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changes produced in a solution represent the changes that would be caused by the same bacteria in a soil, is to base upon the hypothesis that the action of a given species of bacteria in a solution is the same in kind, and approximately the same in degree as is the action of the same species when in a soil.

Both upon *a priori* grounds and as the result of numerous observations during the past few years, we were led to doubt the validity of this hypothesis.[1] A series of experiments was therefore instituted to test the question: Do soil bacteria act in solutions the same as they do in soils? The results of these experiments, with other experiments of collateral bearing we here present and discuss.

We may state in advance that working with pure cultures as well as with soil composites, there is a great divergence in behavior of the same organisms when in soils and in solutions as regards nitrification,[2] denitratation, and ammonification; that some species or races affect their chemical changes in each medium, some in one only, others to different degrees in different media.

Bacteriological Methods.

In all instances strict bacteriological precautions were taken to avoid contamination of the test cultures. In cases of composite or crude inoculations with soil, the soil to be used was taken with aseptic precautions, and the water, media, glassware, etc., were sterile. Unless otherwise stated, the cultures were in cotton-stoppered, Erlenmeyer flasks, and were kept in a dark incubator room at a temperature varying from 30 degrees to 35 degrees. Calcium carbonate was added to all cultures. 400 grams of air-dry soil were used with water sufficient to render one-third saturated, unless otherwise stated.

Before sterilizing, the soil and nitrogenous material (except asparagin) were mixed, the water content made as desired, and the whole flasked, plugged, autoclaved for one hour at 120 degrees, and inoculated as desired. To sterilize asparagin a definite amount was weighed into a graduated flask, and enough ether added to cover the asparagin. After twenty-four hours the ether was evaporated, sterile water added, the asparagin dissolved and made up to a definite volume. The desired amount of this solution was taken with a sterile pipette.

[1] Since the publication of the brief abstract of this paper in Science, 27, p. 988. Fraps (Bul. 106, Tex. Agr. Exp. Sta. p. 8) has noted that nitrification does not proceed in saturated soils, and Lipman in his book "Bacteria in Relation to Country Life," p. 338, says that "With too much (moisture) nitrification was suspended." Failue to nitrify in an almost "waterlogged" sand was also noted by Hoffman (23rd Rept. Wis. Agr. Exp. Sta).

[2] Throughout this article we employ the term ***nitrification*** which has by many writers been used in many divers ways, in what seems its most logical meaning, to designate the change of ammoniacal nitrogen to nitrate nitrogen, and the term ***nitritation*** and ***nitratation*** to mean respectively change to nitrite and nitrate, as has been done by Winogradsky. The term ***denitratation*** is introduced to designate change from the nitrate to some other form containing less oxygen.

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When it was desired to absorb solutions by soil, the soil to be used was dried in an air bath at 100-105 degrees, then 200 or 400 grams of this soil were flasked, plugged, sterilized, and the solution to be absorbed, previously inoculated, was poured upon it.

Three methods of inoculation have been employed: first the desired quantity of fresh soil (the inoculum) was poured into the flask on top of the soil to be inoculated and mixed by thorough shaking; second, the soil inoculum was weighed into a flask containing the nutrient solution, and this mixture poured onto the soil medium in the flask and mixed; third, a bacterial suspension was secured by adding 100 grams of soil to 200 cc. of sterile water and shaking three minutes. Inoculations were then made with the desired amount of the suspension.

Chemical Methods.

Soil Extract.—To the sample of 400 grams of soil were added 10 cc. of chloroform and water sufficient, with that originally in the soil, to make 1200 cc. Shaking in a shaking machine was continued for four hours. After standing over night, the solution was (1) poured off if sufficiently clear, or (2) filtered through a Pasteur-Chamberland filter,[1] or (3) after an aliquot part had been taken for the ammonia determination, the remainder was treated with lime and carbon black and filtered after precipitating the lime with a current of carbon dioxide.

Ammonia.—When nitrogen was added in the form of ammonium sulphate, it was expelled by boiling with a solution of sodium hydroxide. When it was added in organic forms, it was expelled by boiling in the presence of magnesium oxide. In either case the distillate was collected in one-fifth normal hydrochloric acid and titrated with one-tenth normal ammonium hydroxide solution, using cochineal as an indicator.

When the amount of nitrogen was less than the equivalent of 0.1 cc. of one-tenth normal ammonium hydroxide solution, the ammonia was liberated and collected in the same manner, but the amount was determined by Nesslerizing.

Nitrites and Nitrates.—The clarified solution was tested with diphenylamine,[2] which is sensitive to one part of nitrogen in the form of nitrite or nitrate in twenty millions or 0.05 milligrams nitrogen in one liter. In the case of soils where the dilution of the solution was approximately twenty times, the method would show 0.1 milligram nitrogen in 100 cc. of soil solution or about 0.06 milligram in 400 grams of soil.

Nitrites.—The sulphanilic acid method of Griess[3] was used for nitrites.

[1] Bureau of Soils U. S. Dept. Agr. Bul. No. 31. (1906) p. 12.
[2] Treadwell's Analytical Chemistry (1906), 1, p. 341.
[3] Bul. Soc. Chim. (3) 2, (1889); Bureau of Soils, U. S. Dept. Agr. Bul. 31, (1906), p. 41.

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Nitrates.—Nitrates were usually determined by the Tiemann-Schulze method,[1] deduction being made for nitrites. When the amount of nitric oxide liberated was small, a correction was made for the amount insoluble in a concentrated solution of ferrous sulphate.

When the amount of nitrogen in the form of nitrates was very small, it was estimated by the phenol-disulphonic acid method.[2]

Explanation of Tables.

The amounts of ammonia, nitrites and nitrates are expressed in terms of the element nitrogen.

The amounts of nitrogen found at the end of the experiment in different forms of combination are expressed in terms of percentages of the nitrogen added at the beginning of the experiment and in terms of milligrams in 100 cc. of solution. In the case of soil, unless otherwise stated, the total amount of water present with 400 grams of soil was 60 cc., which was sufficient for one-third saturation. In preparing the samples for experiment, the amount of water added was sufficient, together with that originally present in the soil, to make 60 cc. approximately.

Table I.—Showing Nitrification of Both Ammonium

Sample Number.	Date of Inoculation.	Days from Inoculation to Analysis.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
1902	10-17-07	28	Live soil 1866	400			240	$(NH_4)_2SO_4$
1903	"	28	Sterile soil 1866	400			240	$(NH_4)_2SO_4$
1904	"	28	Live soil 1866	400			240	C. S. M.
1905	"	28	Sterile soil 1866	400			240	C. S. M.
1905a	"	28	Omelianski's solu	300	Soil 1866	5	127.3	$(NH_4)_2SO_4$

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Experiment No. 32.—400 grams of soil, No. 1866, from the bed of the greenhouse were placed in a liter Erlenmeyer flask. Water, containing ammonium sulphate to amount of 240 milligrams of nitrogen, was added to make one-third saturation. Another flask was similarly prepared, except that the nitrogen was in the form of cotton-

[1] Treadwell's Anal. Chem. (1904), Vol. 2., p. 360. Zeit. f. Anal. Chem. 14 (1870) p. 401.

[2] Jour. Am. Chem. Soc. 16, (1894); 122, 193. Bureau of Soils, U. S. Dept. Agr. Bul. 31, (1906) p. 39.

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seed meal. Check flasks similarly prepared, but sterile, were provided in each instance. The flasks were kept in the incubator room four weeks at 30-35 degrees.

At the same time Omelianski's solution,[3] containing ammonium sulphate, was inoculated with 5 grams of the same soil and maintained under the same conditions as were the soil cultures. The results appear in Table I.

It is here evident from the soil tests, both with ammonium sulphate and with cottonseed meal, that this soil is in a vigorous nitrifying condition, yet the tests by inoculation in solution give no indication of the presence of nitrate, even by diphenylamin, capable of indicating one part of nitrate in two millions. It may be added that this soil has never nitrified in solution sufficiently to give the diphenylamin reaction, though in soil tests it has repeatedly showed itself to be in reality a vigorous nitrifier.

The entire absence of ammonia in the cultures with cottonseed meal was so striking and unexpected that the samples were again analyzed on December 5, with confirmation of the fact that neither of the cottonseed meal flasks contained ammonia.

This raised the question whether the soil under study had any

SULPHATE AND COTTONSEED MEAL IN SOILS BUT NOT IN SOLUTIONS.

Sample Number.	Percentage of Initial Nitrogen.					Milligrams of Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total recovered.	Recovered as			Unaccounted for.	Total recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
1902	10.00	90.00	34.00	tr.	56.00	40.0	360.0	136.0	tr.	224.0
1903	12.40	87.60	82.00	0.20	5.60	49.6	350.4	328.0	0.8	22.4
Net	------	------	------	------	50.40	------	------	------	0.0	201.6
1904	54.00	46.00	------	tr.	46.00	216.0	184.0	0.0	0.0	184.0
1905	100.00	------	------	------	------	400.0	------	0.0	0.0	------
Net	------	------	------	------	46.00	------	------	------	0.0	184.0
1905a	------	------	0.00	------	------	------	------	0.0	------	------

ammonifying power, and tests were conducted, employing both peptone and cottonseed meal separately and inoculating with soil No. 1866. Each when tested at the end of eight days gave a considerable amount of ammonia, showing the soil to be in normal ammonifying condition. The only probable explanation of the absence of ammonia in this instance is that it was consumed by the nitrite organisms as fast as it was made. It appears also that the nitrite was likewise consumed by the nitrate organisms equally fast.

[3] Centr f. Bak. 2 Ab. 5 537-549.

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TABLE II.—SHOWING NITRIFICATION OF BOTH AMMONIUM SULPHATE AND

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kinds.	Grams.	Kind.	Grams.	Milligrams.	Form.
1909	10-30-07	28	Live soil 1667	400			240	$(NH_4)_2SO_4$
1910	10-30-07	28	Live soil 1667	400			240	C. S. M.
1911	10-30-07	28	Live soil, plat 10	400			240	$(NH_4)_2SO_4$
1912	10-30-07	28	Live soil, plat 10	400			240	C. S. M.
1913	10-30-07	28	Live soil 1867	400			240	$(NH_4)_2SO_4$
1914	10-30-07	28	Live soil 1867	400			240	C. S. M.
1909a	10-30-07	28	Omelianski's solu.	300	Soil 1667	5	127.3	$(NH_4)_2SO_4$
1911a	10-30-07	28	Omelianski's solu.	300	Soil plat 10	5	127.3	$(NH_4)_2SO_4$
1913a	10-30-07	28	Omelianski's solu.	300	Soil 1867	5	127.3	$(NH_4)_2SO_4$

TABLE III.—SHOWING FAILURE TO NITRIFY IN

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2546	8-24-08	28	Live soil 1931a	400			240	$(NH_4)_2SO_4$
2547	8-24-08	28	Live soil 1931a	400			240	$(NH_4)_2SO_4$
2548	8-24-08	28	Omelianski's solution.	377.12	Suspension of soil 1931a.	10	160	$(NH_4)_2SO_4$
2549	8-24-08	28	Omelianski's solution.	377.12	Suspension of soil 1931a.	10	160	$(NH_4)_2SO_4$
2550	8-24-08	28	Live soil 1931b	400			240	$(NH_4)_2SO_4$
2551	8-24-08	28	Live soil 1931b	400			240	$(NH_4)_2SO_4$
2552	8-24-08	28	Omelianski's solution.	377.12	Suspension of soil 1931b.	10	160	$(NH_4)_2SO_4$
2553	8-24-08	28	Omelianski's solution.	377.12	Suspension of soil 1931b.	10	160	$(NH_4)_2SO_4$

Experiment No. 34.—Three samples of soils Nos. 1667, 1867 and plat 10, 400 grams each, were taken. The soils were made to one-third saturation with water carrying 240 milligrams of nitrogen, either as ammonium sulphate or as cottonseed meal. Simultaneous inoculations were made into Omelianski's ammonia solution, using 5 grams of soil as the inoculum. All were done in duplicate. The results are given in Table II.

It is noted in this instance two of the three samples failed utterly

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COTTONSEED MEAL BY SOIL NO. 1867 IN SOIL BUT NOT IN SOLUTION.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates
1909	12.20	87.80	87.80	tr.	0.00	73.2	526.8	526.8	tr.	0.0
1910	81.50	18.50	18.50	tr.	0.00	489.0	111.0	111.0	tr.	0.0
1911	20.70	79.30	79 30	tr.	0.00	124.2	475.8	475.8	tr.	0.0
1912	82.40	17.60	17.60	tr.	0.00	494 4	105.6	105.6	tr.	0.0
1913	1.70	98.30	42.10	tr.	56.20	6.8	398.2	168.4	tr.	224.8
1914	7.30	92.30	42.10	tr.	50.20	29.2	370.8	168.4	tr.	200.8
1909a			0.00	tr.	0.00			0 0		
1911a			0.00	tr.	0.00			0.0		
1913a			0.00	tr.	0.00			0.0		

SOLUTION BUT VIGOROUS NITRIFICATION IN SOILS.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
2546			66.52	0.34	3.38			133.0	0.7	6.8
2547			67.78	1.50	8.45			135.6	3.0	16.9
aver.	26.98	73.07	67.15	0.92	5.92	53.9	146.1	134.3	1.8	11.8
2548			93.78	0.00	0.00			39.8	0.0	0.0
2549			96.36	0.00	0.00			40.9	0.0	0.0
aver.	4.93	95.07	95.07	0.00	0.00	2.1	40.4	40.4	0.0	0.0
2550			53.91	0.85	33.20			107.8	1.6	66.4
2551			62.46	0.88	7.39			124.9	1.8	14.6
aver	21.68	78.32	58.18	0.87	20.24	42.7	157.3	116.3	1.7	41.0
2552			93.60	0.00	0.00			39.8	0.0	0.0
2553			94.38	0.00	0.00			40.1	0.0	0.0
aver.	6.12	93.98	93.98	0.00	0.00	2.6	39.9	39.9	0.0	0.0

to nitrify either in soil or in solution, but that one sample, soil No. 1867, nitrified strongly in soil, though not at all in solution. This soil itself was known to be nearly free from nitrates.

Experiment No. 108.—Two soils were inoculated in duplicate into soils, and at the same time in duplicate into Omelianski's solution. The results in Table III give another instance of failure to nitrify in solutions, though nitrification in soil was vigorous. Though no checks were run, it is known that soil No. 1931 contained practi-

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TABLE IV.—SHOWING BETTER NITRIFICATION IN SOIL.

Sample Number.	Date of Inoculation.	Days from Inoculation to Analysis.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2046	2-10-08	28	Sterile soil 1867	390	Soil 1867	10	240	$(NH_4)_2SO_4$
2047	2-10-08	28	Sterile soil 1867	390	Soil 1867	10	240	$(NH_4)_2SO_4$
2048	2-10-08	28	Omelianski's solu	300	Soil 1867	10	127.3	$(NH_4)_2SO_4$
2049	2-10-08	28	Wiley's solution	300	Soil 1867	10	12.73	$(NH_4)_2SO_4$
2050	2-10-08	28	Extract of soil 1867	300	Soil 1867	10	127.3	$(NH_4)_2SO_4$
2054	2-10-08	28	Omelianski's solu	300	Soil 1867	.2	127.3	$(NH_4)_2SO_4$
2055	2-10-08	28	Wiley's solution	300	Soil 1867	.2	12.73	$(NH_4)_2SO_4$

cally no nitrate, and that the nitrate shown in this table is the result of nitrification during the experiment.

Experiment No. 72.—Cultures were tested by using soil extract as a medium, to ascertain whether some deficiency in the chemical constitution of the solutions used, which might not exist in soil extract itself, was responsible for the failure to nitrify in solutions.

Tests were also made in Wiley's solution[1] and Omelianski's solution using 10 grams of inoculum. The results secured at the end of four weeks are given in Table IV.

The contrast is here again strong between soil cultures Nos. 2046 and 2047, which either upon a basis of percentage of nitrification or upon a basis of milligrams nitrified per cc. of solution show a much greater nitrification than cultures in Omelianski's solution, (Nos. 2048 and 2054), which practically failed to nitrify at all. While the percentage of nitrification in Nos. 2049 and 2055 in Wiley's solution is high, this is not significant, since the absolute amount of nitrates is so small as to be almost negligible. Note initial amounts of nitrogen present. A more nearly correct comparison regarding the nitrifying power of these samples is shown in the last column, indicating only slight nitrification in the liquid medium. While there was nitrification in the soil extract No. 2050, it fell far short of that occurring in the soil itself. While this experiment, taken alone, would tend to indicate that soil extract contains something favorable to nitrification which is lacking in the artificial solutions, this conclusion is not supported by other evidence. The conclusion that soil as a medium furnishes a much more sensitive means for detection of nitrification than do the usual solutions, is, however, supported by the evidence throughout.

[1] Wiley, Yearbook, U. S. Dept. Agr. for 1895, p. 97.

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THAN IN SOIL EXTRACT OR IN THE USUAL CULTURE SOLUTIONS.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen Per 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates
2046	19.00	81.00	59.50	0.10	21.50	76.0	324.0	238.0	0.0	86.0
2047	10.00	90.00	64.40	0.00	25.60	40.0	360.0	257.6	0.0	102.4
aver.	14.50	85.50	61.95	0.05	23.55	58.0	342.0	247.8	0.0	94.2
2048	1.20	98.80	97.00	0.00	1.80	0.5	42.0	41.2	0.0	0.8
2049	12.90	87.10	42.90	0.00	44.20[2]	0.6	3.7	1.8	0.0	1.9
2050	5.70	94.30	81.20	0.10	13.10	2.4	40.1	34.5	tr.	5.6
2054	12.20	87.80	87.10	0.00	0.70	5.5	37.0	37.0	0.0	tr.
2055	9.70[1]	109.70	102.30	0.00	7.40[2]	0.41	4.7	4.4	0.0	0.3

[1] Excess.
[2] This percentage has slight significance because of the small amount of initial nitrogen.

Experiment No. 72.—Duplicate cultures of this experiment were analyzed at the end of sixty-four days. During this additional time some slight nitrification had occurred in the cultures which showed no nitrification at first analysis, but the superiority of soil as a medium for nitrification is even more apparent at the second than at the first analysis. (Compare Tables IV and V, last column.)

Basing nitrification upon the amount of nitrate produced per 100 cc. of solution, it is seen that the process is sixty-eight times as rapid in the soil water *in situ* as it is in Omelianski's or Wiley's solutions, and thirty-nine times as fast as it is in an extract of the same soil.

It seems clear from this experiment that not only are results of four week tests in solutions, such as those of Wiley, Omelianski or Ashby, worthless as indicative of the nitrifying powers of soils tested by them, but that results which are negative at the end of four weeks may indicate some nitrification if the cultures be allowed to stand for a longer time.

Experiment No. 73.—To 400 grams each of live soils Nos. 1867, 1667 and 2069 were added in the usual way 240 milligrams of nitrogen as cottonseed meal.

Flasks of Omelianski's and of Wiley's solutions were also inoculated with each of these soils. Determinations were made upon all after four weeks' incubation.

The results are presented in Table VI.

In the last column of Table VI it is noted that soils Nos. 1867 and 2069 gave a large nitrification in soil, but a nearly negligible quantity in Omelianski's or Wiley's solutions, while the third soil failed to nitrify to any extent in any medium.

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TABLE V.—SHOWING RESULTS OF NITRIFICATION

Sample Number.	Date of Inoculation.	Days of Incubation.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2165	2-10-08	64	Sterile soil 1867	300	Soil 1867	10	240	$(NH_4)_2SO_4$
2166	2-10-08	64	Sterile soil 1867	300	Soil 1867	10	240	$(NH_4)_2SO_4$
2167	2-10-08	64	Omelianski's solution.	300	Soil 1867	10	127.3	$(NH_4)_2SO_4$
2168	2-10-08	64	Wiley's solution	300	Soil 1867	10	12.73	$(NH_4)_2SO_4$
2169	2-10-08	64	Extracts of soil 1867.	300	Soil 1867	10	127.3	$(NH_4)_2SO_4$
2173	2-10-08	64	Omelianski's solution.	300	Soil 1867	.2	127.3	$(NH_4)_2SO_4$
2174	2-10-08	64	Wiley's solution	300	Soil 1867	.2	12.73	$(NH_4)_2SO_4$

TABLE VI.—SHOWING NITRIFICATION

Number Sample.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kinds.	Grams.	Kind.	Grams.	Milligrams.	Form.
2060	2-13-08	28	Live soil 1867	400			240	C. S. M.
2057	2-13-08	28	Sterile soil 1867	400			0.12	C. S. M.
2061	2-13-08	28	Live soil 1667	400			240	C. S. M.
2058	2-13-08	28	Sterile soil 1667	400			0.12	C. S. M.
2062	2-13-08	28	Live soil 2069	400			240	C. S. M.
2059	2-13-08	28	Sterile soil 2069	400			0.12	C. S. M.
2063	2-13-08	28	Wiley's solution	300	Soil 1867	.2	12.7	$(NH_4)_2SO_4$
2064	2-13-08	28	Wiley's solution	300	Soil 1667	.2	12.7	$(NH_4)_2SO_4$
2065	2-13-08	28	Wiley's solution	300	Soil 2069	.2	12.7	$(NH_4)_2SO_4$
2066	2-13-08	28	Omelianski's sol	300	Soil 1867	.2	127.	$(NH_4)_2SO_4$
2067	2-13-08	28	Omelianski's sol	300	Soil 1667	.2	127.	$(NH_4)_2SO_4$
2068	2-13-08	28	Omelianski's sol	300	Soil 2069	.2	127.	$(NH_4)_2SO_4$

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TESTS IN SOLUTIONS AND IN SOILS AT 64 DAYS.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
2165	6.80[1]	106.80	30.80	0.00	76.00	27.2[2]	427.2	123.2	0.0	304.0
2166	1.20[1]	101.20	28.80	0.00	77.40	4.8[2]	404.8	95.2	0.0	309.6
aver.	4.00[1]	104.00	27.30	0.00	76.70	16.0[2]	416.0	109.2	0.0	306.8
2167	8.00[1]	108.00	92.40	0.00	10.60	1.3[2]	43.8	39.3	0.0	4.5
2168	3.40	96.60	6 60	0.00	90.00[1]	0.2	4.1	0.3	0.0	3.8
2169	4.70	95.30	77.20	0.00	18.10	2.0	40.5	32.8	0.0	7.7
2173	6.90[1]	106.90	97.70	1.30	9.20	2.8[2]	45.8	41.4	0.6	3.9
2174	1.60[1]	101.60	26.40	tr.	75.20[1]	0.1[2]	4.3	1.1	tr.	3.2

[1] Excess.

[2] These percentages have small significance because of the small amount of nitrogen.

IN SOILS, NOT IN SOLUTIONS.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates
2060						155.6	244.4	14.0	0.0	230.4
2057						0.4	2.4	2.4	0.0	1.6
net	39.90	60.10	2.90	0.00	57.20	158 0	242.0	11.6	0.0	228.8
2061						318.0	82.0	78.4	0.0	3.6
2058						1.0	1.0	0.6	0.0	0.4
net	79.75	20.25	19.45	0.00	0.80	319.0	81.0	77.8	0.0	3.2
2062						260.0	140.0	33.6	6.4	106.4
2059						1.3	0.7	0.3	0.0	0.4
net	65.18	34.82	8.32	1.60	24.90	260.7	139.3	33.3	6.4	99.6
2063	41.00	59.00	0.00	3.60	50.00[1]	1.8	2.5	0.0	0.2	2.5
2064	41.90	58.10	33.00	0.00	25.10[1]	1.8	2.5	1.4	0.0	1.1
2065	50.10	49.90	39.60	tr.	10.30[1]	2.2	2.1	1.7	tr.	0.4
2066	55.10	44.90	40.90	0.20	4.00	23.4	19.1	17.4	tr.	1.7
2067	61.40	38.60	37.60	tr.	1.00	26.1	16.4	16.0	tr.	0.4
2068	50.90	49.10	48.10	tr.	11.00	21.7	20.8	20.4	tr.	0.4

[1] Not significant on account of the very small amount of initial nitrogen.

[2] C. S. M.—Cottonseed Meal.

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TABLE VII.—SHOWING NITRIFICATION IN

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2025	2-10-08	14	Sterile soil 1867	490	Soil 1867	10	120	Peptone.
2026	2-10-08	14	Sterile soil 1867	490	Soil 1867	10	120	C. S. M.
2027	2-10-08	14	Peptone water	200	Soil 1867	10	60	Peptone.
2028	2-10-08	14	C. S. M. water	200	Soil 1867	10	60	C. S. M.

TABLE VIII.—SHOWING INFLUENCE OF NUMBER

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
1962	12-2-08	28	Sterile soil 1867	390	Soil 1867	10	240	$(NH_4)_2SO_4$
1963	12-2-08	28	Sterile soil 1867	350	Soil 1867	50	240	$(NH_4)_2SO_4$
1964	12-2-08	28	Sterile soil 1867	300	Soil 1867	100	240	$(NH_4)_2SO_4$
1965	12-2-08	28	Sterile soil 1867	200	Soil 1867	200	240	$(NH_4)_2SO_4$
1966	12-2-08	28	Live soil 1867	400			240	$(NH_4)_2SO_4$
1967	12-2-08	28	Sterile soil 1867	400			240	$(NH_4)_2SO_4$

Making proper allowance for the very small quantity of initial nitrogen in Omelianski's and Wiley's solutions, the same conclusion is reached from the percentage of nitrogen recovered as nitrates. Two of the soils could nitrify vigorously in soils but only slightly in solutions.

Experiment No. 69a.—Four cultures were made; two in soils, one with peptone and one with cottonseed meal; two in solutions, one with peptone and one with cottonseed meal. They were inoculated in parallel with the same bacterial suspensions from soil No. 1867. Analysis on the fourteenth day gave the results shown in Table VII.

While nitrification progressed to a marked extent in both soil cultures, the solutions gave no reaction with diphenylamin. Though no checks were run with this test to determine the amounts of nitrates in these soils, our constant experimentation with them and frequent analyses assure us that there was barely a trace, or no nitrate at all, present in the soil when the experiment was set up. The amount shown by the analysis is due to nitrification during the experiment.

Experiments 56 and 57.—It seemed possible that the amount of

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14 DAYS IN SOILS, NOT IN SOLUTIONS.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
2025	51.60	48.40	11.20	1.50	37.20	108.2	96.8	22.4	3.0	74.4
2026	66.30	33.70	2.80	1.50	30.90	132.6	67.4	5.6	3.0	61.8
2027	29.60	70.40	70.40	0.00	0.00	8.9	21.1	21.1	0.0	0.0
2028	61 70	38.30	38.30	0.00	0.00	18.5	11.5	11.5	0.0	0.0

OF BACTERIA UPON RAPIDITY OF NITRIFICATION.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
1962	-------	-------	60 90	0.20	lost.	-------	-------	248.6	0.8	lost.
1963	29.90	71.10	58.20	0.20	17.90	115.6	284.6	212.8	0.8	71.6
1964	34.20	65.80	42.70	0.20	28.10	136.8	263.2	170.8	0.8	97.4
1965	21.40	78.60	44.10	0.20	34.50	85.6	314.4	176.4	0.8	138.0
1966	4.60[1]	104.60	12.60	0.20	91.80	17.6[1]	417.6	50.4	0.8	367.2
1967	31.20	68.80	68.60	0.20	0.00	124.8	275.2	274.4	0.8	0.0

[1] Excess.

inoculum used might be an important factor in determining the amount, or at least the rapidity, of nitrification in early stages of incubation. To throw light upon this point, parallel cultures were made by mixing the same soil, sterile and alive, in different proportions, thus varying practically only one factor, the quantity of live organisms present. Experiment 56 consisted of such a series with nitrogen supplied in the form of ammonium sulphate; experiment 57, with nitrogen in the form of cottonseed meal.

The results are given in Tables VIII and IX.

In Table VIII there is shown a remarkably regular increase in nitrification as the quantity of inoculum increases. In Table IX, where cottonseed meal was used, if the third result be disregarded, the same relation holds true. The discrepancy in the behavior of soil No. 1970 is inexplicable, but it probably does not vitiate the general conclusions supported by these two experiments, viz, that with increase in the inoculum there is nearly a corresponding increase in the total amount of nitrification at the end of four weeks.

When tests of nitrifying power are made in the soil itself, by add-

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TABLE IX.—SHOWING INFLUENCE OF QUANTITY OF BACTERIA

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
1968	12-5-08	28	Sterile soil 1867	390	Soil 1867	10	240	C. S. M.
1969	12-5-08	28	Sterile soil 1867	350	Soil 1867	50	240	C. S. M.
1970	12-5-08	28	Sterile soil 1867	300	Soil 1867	100	240	C. S. M.
1971	12-5-08	28	Sttrile soil 1867	200	Soil 1867	200	240	C. S. M.
1972	12-5-08	28	Live soil 1867	400			240	C. S. M.
1973	12-5-08	28	Sterile soil 1867	400			240	C. S. M.

TABLE X.—SHOWING NO NITRIFICATION IN SOLUTIONS

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
1974	12-12-07	28	Sterile soil 1867 Water	399.5 200	Soil 1867	0.5	360	C. S. M.
1975	12-12-07	28	Sterile soil 1867 Water	300 200	Soil 1867	100	360	C. S. M.
1976	12-12-07	28	Live soil 1867 Water	400 200			360	C. S. M.
1977	12-12-07	28	Sterile soil 1867 Water	399.5 200	Soil 1867	0.5	360	$(NH_4)_2SO_4$
1978	12-12-07	28	Sterile soil 1867 Water	300 200	Soil 1867	100	360	$(NH_4)_2SO_4$
1979	12-12-07	28	Live soil 1867 Water	400 200			360	$(NH_4)_2SO_4$

ing the material to be nitrified directly to the soil, it is evident that there is initially a much larger number of organisms than when 200 milligrams or even 10 grams of the soil are used as an inoculum. We may regard the direct soil tests in our work as having the equivalent of an inoculum of 400 grams.

The idea that increase in the quantity of the inoculum brings increase in nitrification arouses the suspicion that perhaps the low nitrification, or entire failure to nitrify, found by the Ashby[1] method with an inoculum of only 200 milligrams of soil, may be due to the smallness of the inoculum used.

Experiment No. 58.—This experiment was set up to test this lat-

[1] Jour. Chem. Soc. 85, 1158.

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UPON RAPIDITY OF NITRIFICATION OF COTTONSEED MEAL.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites	Nitrates.			Ammonia.	Nitrites	Nitrates
1968	76.20	23.80	17.50	tr.	6.30	304.8	95.2	70.0	tr.	25.2
1969	70.10	29.90	13.30	tr.	16.60	280.4	119.6	53.2	tr.	66.4
1970	74.50	25.50	22.40	tr.	8.10	298.0	102.0	89.6	tr.	12.4
1971	60.20	39.80	4.90	tr.	34.90	240.8	159.2	19.6	tr.	139.6
1972	53.00	47.00	0.00	tr.	47.00	212.0	188.0	0.0	tr.	188.0
1973	97.50	2.50	0.00	tr.	2.50	390.0	10.0	0.0	tr.	10.0

C. S. M.– Cottonseed Meal.

EVEN WHEN VERY LARGE INOCULUM WAS USED.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
1974	70.60	29.40	29.40	0.00	0.00	97.8	40.7	40.7	0.0	0.0
1975	48.90	51.10	51.10	tr.	0.00	67.7	70.8	70.8	tr.	0.0
1976	78.30	21.70	21.70	0.00	0.00	108.4	30.1	30.1	0.0	0.0
1977	45.40	54.60	54.60	0.00	0.00	62.9	75.6	75.6	0.0	0.0
1978	lost	lost	lost	lost	0.00	lost	lost	lost	lost	0.0
1979	43 20	56.80	56.70	tr.	0.00	60.0	78.5	78.5	tr.	0.0

C. S. M.—Cottonseed Meal.

ter point: to determine whether the failure to nitrify in solutions can fairly be attributed to the smallness of the inoculum used.

A series of tests was made in solutions, varying the amount of inoculum. In order to maintain conditions as nearly parallel as possible, the quantity of soil used in each case was the same, larger or smaller amounts of it being sterilized to give the desired variations in the number of live organisms present.

Thus in soil No. 1974, 399.5 grams of sterile soil+0.5 gram of the same live soil were used, while in No. 1979, 0 grams of sterile soil+400 grams of live soil were used. The other numbers gave intermediate conditions. Solution sufficient to cover the soil to a depth of 2.5 cm. was employed in each case, the solution also carried nitrogen

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TABLE XI.—SHOWING FAILURE TO

Nitrogen 240 Mgs. as Ammonium Sulphate.

Sample Number.	Date of Inoculation.	Days from Inoculation to Analysis.	Medium.		Inoculum.	
			Kind.	Amount.	Kind.	Amount.
2621	9-10-08	28	Sterile soil 1549 Water to ⅔ saturat'n	400 60	Suspension of Soil number 1867	10
2622	9-10-08	28	Sterile soil 1549 Water to ⅔ saturat'n	400 60	Suspension of Soil number 1867	10
2623	9-10-08	28	Sterile soil 1549 Water to saturat'n	400 100	Suspension of Soil number 1867	10
2624	9-10-08	28	Sterile soil 1549 Water to saturat'n	400 100	Suspension of Soil number 1867	10
2627	9-10-08	28	Sterile soil 1783 Water to ⅔ saturat'n	400 100	Suspension of Soil number 1867	10
2628	9-10-08	28	Sterile soil 1783 Water to ⅔ saturat'n	400 100	Suspension of Soil number 1867	10
2629	9-10-08	28	Sterile soil 1783 Water to saturati'n	400 144	Suspension of Soil number 1867	10
2630	9-10-08	28	Sterile soil 1783 Water to saturati'n	400 144	Suspension of Soil number 1867	10
2631	9-10-08	28	Sterile soil 1931 Water to ⅓ satutat'n	400 60	Suspension of Soil number 1867	10
2632	9-10-08	28	Sterile soil 1931 Water to ⅓ saturat'n	400 60	Suspension of Soil number 1867	10
2635	9-10-08	28	Sterile soil 1931 Water to saturation	400 180	Suspension of Soil number 1867	10
2636	9-10-08	28	Sterile soil 1931 Water to saturation	400 180	Suspension of Soil number 1867	10

at the rate of 240 milligrams per 400 cc. The culture was frequently shaken, sampled, and tested by diphenylamine with negative results. At the end of four weeks, analysis was also made with still no nitrification, as is shown in Table X.

A comparison of these results with those of experiments 56 and 57, which were inoculated with the same soils, brings out again clearly the failure of the soil to nitrify at all in the solutions, although the same soil can nitrify vigorously in the same period, as is shown by actual soil tests.

Experiment No. 58 demonstrates conclusively that the differences existing between results of cultures in soils and in solutions are not to be explained by the differences in the quantities of inoculum used.

Experiment 211.—It being demonstrated that the water relation is a very important one as regards nitrification, and that nitrification proceeds not at all, or very slightly in solutions, during the time of our experiments with the soils under consideration, but vigorously in the soil itself, it became desirable to determine whether nitrification can proceed in saturated soils as well as in those of less water con-

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NITRIFY IN SATURATED SOILS.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates
2621	------	------	24.51	2.25	24.29	------	------	98.0	9.0	97.2
2622	------	------	24.09	3.37	26.08	------	------	96.4	13.5	104.3
aver.	50.52	49.48	24.30	2.81	25.18	202.1	197.9	97.2	11.3	100.7
2623	------	------	50.41	0.10	0.00	------	------	121.0	0.3	0.0
2624	------	------	52.79	0.10	0.00	------	------	125.4	0.3	0.0
aver.	48.30	51.70	51.60	0.10	0.00	116.5	123.5	123.2	0.3	0.0
2627	------	------	16.80	0.25	23.82	------	------	40.3	0.6	57.2
2628	------	------	22.41	0.37	22.86	------	------	53.8	0.9	54.8
aver.	57.06	42.94	19.60	0.31	23.33	134.9	103.1	47.1	0.8	56.0
2629	------	------	68.02	0.10	0.00	------	------	105.0	0.2	0.0
2630	------	------	57.42	0.12	0.00	------	------	95.7	0.2	0.0
aver.	39.67	60.33	60.22	0.11	0.00	66.2	100.5	100.3	0.2	0.0
2631	------	------	35.01	0.23	44.79	------	------	140.0	0.9	179.2
2632	------	------	26.01	0.23	46.67	------	------	126.4	0.9	186.7
aver.	23.76	76.24	30.51	0.23	45.73	84.0	316.0	133.2	0.9	182.8
2635	------	------	48.41	0.10	tr.	------	------	57.9	0.1	tr.
2636	------	------	45.51	0.10	tr.	------	------	60.7	0.1	tr.
aver.	55.44	44.56	44.46	0.10	tr.	73.9	59.4	59.3	0.1	tr.

tent. To this end cultures in three different soils were prepared, some bearing water to one-third, two-thirds, and some to complete saturation. The cultures were inoculated with a suspension of soil No. 1867.

The results are given in Table XI.

It is seen that there was no trace of nitrification in the saturated soil in the case of two soils and only a trace with the other soil, though nitrification proceeded well in all soils when of two-third or one-third saturation.

In order to have a still more crucial test of nitrifying activity in soil as compared with that in solution, two portions of Omelianski's solution were prepared in the usual way, inoculated; one lot was incubated as a solution, the other portion was absorbed by sterile soil of such quantity as to render the culture about two-thirds saturated. Also an extract of soil with ammonium sulphate added to it in the usual quantity was inoculated and similarly mixed with soil. Suitable control cultures were set up. The results are given in Table XII.

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TABLE XII.—SHOWING AMOUNT OF NITRIFICATION IN SOLUTION

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2084	2-3-08	28	Omelianski's sol...	240	Soil 1867.....	10	101.8	$(NH_4)_2SO_4$
2085[1]	2-3-08	28	Sterile soil 1867...	400	Soil 1867.....	5	50.9	$(NH_4)_2SO_4$
2086	2-3-08	28	Ext'ct of soil 1867.	240	Soil 1867.....	10	101.8	$(NH_4)_2SO_4$
2088	2-3-08	28	Ext'ct of soil 1867.	240	Soil 1867.....	10	101.8	$(NH_4)_2SO_4$
2087[1]	2-3-08	28	Sterile soil 1867...	400	Soil 1867.....	5	50.9	$(NH_4)_2SO_4$
2089	2-3-08	28	Sterile soil 1867...	400	Soil 1867.....	5	50.9	$(NH_4)_2SO_4$

TABLE XIII.—SHOWING NITRIFICATION BY

Sample Number.	Date of Inoculation.	Time of Incubation. Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2051	2-8-08	28	Sterile soil 1867...	390	Percolator effluent	10	240	$(NH_4)_2SO_4$
2052	2-8-08	28	Sterile soil 1867...	390	Percolator effluent	10	240	$(NH_4)_2SO_4$
2053	2-8-08	28	Ext'ct of soil 1867.	800	Percolator effluent	10	127.8	$(NH_4)_2SO_4$

It is seen from the first two numbers that, making proper allowances for the results of the control cultures, nitrification was vastly greater in the solution absorbed by soil than in the same solution not so absorbed, a conclusion which is clearly justified either by basing nitrification upon a per cent basis or on the amount of nitrate produced per 100 cc. of liquid in the medium.

NITRIFYING SEWER ORGANISMS.

Small quantities of nitrifying earth from the sewer beds of Lawrence, Mass., were obtained through the kindness of Dr. Stephen DeM. Gage. These samples, thrown into ammonium sulphate solution, nitrified vigorously from the start. A quantity of finely ground coke was placed in a percolator, inoculated with this nitrifying sewer-

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AND IN THE SAME SOLUTION ABSORBED BY SOILS.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
2084	21.60	78.40	53.50	tr.	24.90	9.2	33.3	22.7	tr.	10.6
2085	14.01[2]	114.00	0.00	0.00	114.00	6.0[2]	48.5	0.0	0.0	48.5
2086	37.20	62.80	47.20	1.60	14.00	16.5	26.0	20.0	0.7	6.0
2088	95.70	4.30	0.00	0.40	3.90	40.8	1.7	0.0	0.2	1.7
net				1.20	10.10				0.5	4.
2087	11.60[2]	111.60	0.00	0.00	111.60	4.9	47.4	0 0	0.0	47.4
2089	58.50	41.50	19.80	0.00	21.70	24.9	17.6	8.4	0.0	9.2
net				0.00	89.90				0.0	38.2

[1] In 2085, 120 cc. of Omelianski's solution were inoculated with 5 g of soil 1867 and then poured over 400 g. of sterile soil. In 2087, 120 cc. soil extract + ammonium sulphate were inoculated and then poured on soil in similar manner.
[2] Excess.

SEWER ORGANISMS IN SOIL AND IN SOLUTION.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates
2051	10.60	89.40	80.50	0.00	8.90	42.4	357.6	322.0	0.0	35.6
2052	19.60	80.40	73.50	0.00	6.90	78.4	321.6	294.0	0.0	27.6
aver	15.10	84.90		0.00	7.90	60.4	339.6	309.0	0.0	31.6
2053	1.80[1]	101.80	86.50	0.00	15.30	0.8[1]	43.3	36.8	0.0	6.5

[1] Excess.

bed material and ammoniacal solution poured through it once or twice daily. In this manner the coke of the percolator soon came to a still more vigorous nitrifying condition.

The effluent from this percolator formed excellent inoculating material for nitrification.

Experiment No. 72.—Inoculations were made into soil and into soil extract with the nitrifying effluent from the coke-filled percolator bearing the sewer organisms. The cultures were analyzed at the end of twenty-eight days with the results shown in Table XIII.

These cultures nitrified more vigorously in solutions than any cultures heretofore examined, and more vigorously than any of the soils among the many that we have tested during the past two years. Not only this, but basing the nitrification upon the number of grams of

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TABLE XIV.—SHOWING FAILURE OF PURE

Nitrogen 240 Mgs. as Ammonium Sulphate.

Sample Number.	Date of Inoculation.	Days from Inoculation to Analysis.	Medium.		Inoculum.	
			Kind.	Amount.	Kind.	Amount.
2606	9-7-08	28	Sterile 1867 Water to ⅓ saturation	400 60	Organism {ite ate	1 cc.
2607	9-7-08	28	Sterile 1867 Water to ⅓ saturation	400 60	Organism {ite ate	1 cc.
2610	9-7-08	28	Sterile 1867 Water to saturation	400 180	Organism {ite ate	1 cc.
2611	9-7-08	28	Sterile 1867 Water to saturation	400 180	Organism {ite ate	1 cc.

nitrogen in the medium, it is seen that there was a larger per cent of nitrification in the solution than in the soil culture, a condition which is also without parallel in our experiments with cultures inoculated with soils.

In numerous tests, this sewer culture has proved a vigorous nitrifier in ammoniacal solutions of various compositions; it also nitrifies well in soil.

Here then is, evidently, a nitrifying organism or group of nitrifying organisms, differing radically in physiological relations from those usually found in soils here, in that it can nitrify even better in solutions than in soils.

TEST WITH PURE CULTURES.

Experiment 210.—Tests of nitrification in the presence of different amounts of water were also made, using as the inoculum 1 cc. each of cultures of pure nitrite and nitrate forming organisms[1] isolated by the Stevens-Temple silicate medium.[2]

The results of this experiment are given in Table XIV.

Here again there was large nitrification in soil cultures of one-third saturation, but no nitrification in the saturated soils.

This result is particularly significant in that it shows that the failure to find nitrates in solution and in very wet soils is in no way due to their reduction or destruction otherwise by organisms accidentally present.

[1] These cultures were pure in the sense that Winogradsky used the term, i. e., they would not render bouillon turbid, and they formed nitrite or nitrate respectively from appropriate lower nitrogen compounds.

[2] A convenient mode of preparing Silicate Jelly Cent. f. Bak. II ab. 21, 1908. 84.

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CULTURE TO NITRIFY IN SATURATED SOILS.

	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.					
			Recovered as						Recovered as		
Number.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrite.	Nitrate.	Initial.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrite.	Nitrate.
2606	------	------	45.51	0.15	12.53	400	------	------	182.	0.6	50.1
2607	------	------	46.35	0.38	11.06	400	------	------	185.4	1.5	44.2
aver	42.29	57.71	45.93	0.26	11.78	400	169.1	230.9	183.7	1.	47.2
2610	------	------	44.11	0.07	0.00	133	------	------	58.7	tr.	0.0
2611	------	------	44.74	tr.	0.00	133	------	------	59.5	tr.	0.0
aver	65.53	44.47	44.47	0.04	0.00	133	78.9	59.1	59.1	tr.	0.0

BASIS FOR COMPARISON.

It is difficult to determine what is the most useful basis for comparing bacterial activity in soils with the activity of bacteria in solutions, whether to base the comparison on:

(1) The per cent of nitrogen originally present that is converted into some other form of nitrogen, or

(2) To compare the number of milligrams of nitrogen converted per cubic centimeter of solution with the number of milligrams of nitrogen per cubic centimeter of soil water so converted, or

(3) To compare the number of milligrams of nitrogen converted per cubic centimeter of solution with the number of milligrams of nitrogen converted per gram of moist soil.

To compare the percentages of original nitrogen converted in two different media, one weak and the other strong, as in Nos. 2049 and 2055 (see Table IV), is manifestly an unfair measure of the nitrifying power of the cultures, since a very weak nitrifier might bring about a nitrification of nearly 100 per cent in the weak medium, while a very vigorous nitrifier might nitrify to less than 40 per cent in the more concentrated medium. In such instances, a comparison of the number of milligrams of nitrogen converted per gram of medium or per cc. of liquid present, is more significant, though this comparison would also be improper, if the nitrification reached such an amount in the weaker medium as to justify the belief that cessation of nitrification was caused by lack of suitable material to work upon.

The nitrifying organisms undoubtedly live and function in the moisture in the soil, so that from the viewpoint of measuring the

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activity of the organisms, the second method mentioned above seems most useful. This method of comparison, however, probably tends to exaggerate the value of the changes occurring, and from a practical viewpoint, a comparison by the third method is probably the most serviceable, since it pictures approximately the relative nitrifying power of two cultures of equal weight. Each comparison has its special uses, and to enable the readers to make such comparisons as are desired, data are given to admit of the use of each of the comparisons suggested.

A comparison of nitrification in soils with nitrification in solutions is probably of very little significance except for the special purpose of this present article, unless some relation can be established showing that the vigor of nitrification in a certain solution can be taken as an index of the nitrifying vigor of the soil used to inoculate the solution.

General Considerations.

The evidence of the tables presented, together with the results of numerous other experiments during our experience of the last two years, forces the conclusion that not all soils which can bring about vigorous nitrification of ammonium sulphate and cottonseed meal in soils in four weeks can nitrify in solutions during that time. Numerous instances show that among the natural soils of this locality few or none can cause nitrification in solution in four weeks, if at all. It is established also that some of these soils which cause nitrification not at all or slightly in Omelianski's, Ashby's, Wiley's, or other ammoniacal solutions, can still nitrify vigorously as soils. It is also brought out that the failure to nitrify is not due to the fact that a small inoculum is used in solution, since in the experiments given in detail there was no nitrification even when 400 grams of the live soil were used as an inoculum, and repeated experiments have also shown that the presence of water to or above the point of saturation inhibits nitrification with the soils here used. Notwithstanding this fact, sewer-bed soil nitrified as well in solutions as it did in soils.

From these facts, it seems that no trustworthy, reliable evidence as to the actual nitrifying power of a soil can be gained by inoculating the soil into solutions in the usual way, unless in the case of soils which are naturally very wet, offering practically the conditions obtaining in a solution. If negative results are had from solution tests, it may well be, as is the case of certain soils of this locality, that a type of nitrifying organism or composite of organisms is present which is capable of nitrifying in soils, but not in solutions; and that though the result is of negative indication, the soil may in reality be a vigorous nitrifier.

If positive results are had, it may be that the soil contains an organism similar to the sewer organisms experimented with, which ni-

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trified more vigorously in solutions than in soils, and that while the indication given by the test is of vigorous nitrifying power, the soil may in reality be of low nitrifying power.

Tests by the method of liquid cultures are not of value even for purposes of comparing the nitrifying power of two soils, since two soils may nitrify to different degrees and yet both give negative results in solutions, or one bearing a vigorous soil-nitrifier may give a negative result, and another bearing a vigorous solution-nitrifier, though weak as a soil-nitrifier, may give a strong, positive result.

It seems, then, that to gain a useful indication of the nitrifying vigor of a soil, the soil itself must be used as a medium. To picture conditions as they are in the field, the field conditions must be approximated as nearly as possible. With varying soil compositions, temperature, light and water relation and a bacterial flora varying in species and vigor, the conditions are very complex and no laboratory tests can ever entirely represent them. It must, however, be the aim of the Soil Bacteriologist to approach as nearly as possible the ideal. *One imperative step is the testing of the activities of soil bacteria in soils rather than in solutions.*

Summary.

(1) Many soils which can nitrify ammonium sulphate and cottonseed meal mixed with them, fail to nitrify ammonium sulphate and cottonseed meal when used as the inoculum for solutions, such as those of Omelianski, Wiley, and Ashby.

(2) Nitrification is *nil* or very slight in saturated soils.

(3) Nitrification in some soils proceeds as fast as ammonification, converting the ammonia to nitrate as fast as it is rendered available by the ammonifying organisms.

(4) Nitrification in extract of soil is, in some instances, very slight as compared with nitrification in the soil itself.

(5) Nitrification in soils increases in intensity with the amount of inoculum used.

(6) Some nitrifying soils do not nitrify when placed in solutions even though a very large inoculum is used.

(7) Nitrifying organisms from sewer beds nitrified better in solutions than in soils.

(8) Tests in solutions are not adequate to indicate the nitrifying vigor of a soil.

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THE COLORIMETRIC DETERMINATION OF NITRATES IN SOIL SOLUTIONS CONTAINING ORGANIC MATTER.

By W. A. SYME.

The accurate determination of nitrates in soil solutions by the colorimetric method with phenoldisulphonic acid and ammonia is a matter of some difficulty on account of the large number of interfering substances which may be present in the solution. Chlorides may cause a loss of nitric acid when the phenoldisulphonic acid is added to the residue left on evaporation. Iron salts affect the color. Nitrites interfere by producing a yellow color with the reagents like that caused by nitrates. These disturbing factors can be removed to a considerable extent—the chlorides by adding silver sulphate, the iron salts with sodium carbonate, and the nitrites may be determined separately by the Griess method.

The presence of organic matter in the soil extract causes trouble in several ways. In the first place, the solution may be so intensely colored that it can not readily be decolorized with carbon black; secondly, the organic matter may reduce the nitrates, thereby causing a loss of nitric acid; and thirdly, the strong acid acting on the organic matter produces substances of foreign color which can not be matched by the pure nitrate standards.

The object of the work reported in this paper was to see if potassium permanganate could be used to remove organic matter from soil extracts. The extracts were prepared for some work on nitrification now in progress in this laboratory, the method of preparation being as follows: 400 grams of soil were shaken four hours with 1,200 cc. of water containing a little chloroform. The solutions were filtered through a porcelain tube.[1] The filtrates were strongly colored when the soils contained much organic matter. The solution from soil 1867, a soil from a compost heap and the one most favorable for the nitrification experiments, was very rich in organic matter and could not be satisfactorily clarified by shaking with carbon black. When this solution was evaporated to dryness, the residue treated with phenoldisulphonic acid and made alkaline with ammonia, the resulting solution had a brownish yellow color quite different from the clear lemon-yellow given by a pure nitrate solution.

The method for treating this solution, and others of the same kind, was as follows: Heat 50 cc., or any convenient portion to 60-70 degrees, and add 1 cc. of dilute sulphuric acid (1:5). Add from a burette a dilute solution of potassium permanganate (5 to 10 gm. per liter) until in excess and heat fifteen minutes on a water-bath, adding more permanganate from time to time, if necessary to have an excess. Remove the brown precipitate by filtering into an evaporating dish, make the filtrate slightly alkaline with sodium carbonate and evaporate to dryness on the water-bath. Add water to the resi-

[1] Bulletin 31, Bureau of Soils, p. 12.

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due and filter into a 50 cc. flask, wash the residue on the filter, and dilute to the mark. We now have 50 cc. of a colorless soil solution nearly free from organic matter. Nitrates can now be determined by the usual colorimetric method, remembering that if nitrite were present in the original solution, it would be oxidized to nitrate.

If a soil solution, after treatment in the way described, is evaporated and the color, developed in the usual way, is compared with that given by a portion of the same solution not so treated, the difference is very marked.

The evaporation of the soil solution with sodium carbonate removes manganese and iron, but enough nitrous acid may be taken up from the air to give an appreciable color with the nitrite reagent.

Carbonaceous matter was not entirely removed by the treatment with permanganate, though the coloring matter was destroyed and the residue left on evaporating the solution to dryness on the water-bath was colorless. The quantity of carbonaceous matter left by the permanganate was not enough to cause serious trouble when the phenoldisulphonic acid was added. The effect of the permanganate treatment can be readily seen by evaporating equal volumes of the same soil solution with and without permanganate and comparing the residues as to color, quantity of organic matter and behavior on ignition.

The method was tested by having an associate to prepare a number of solutions by adding known quantities of nitrate to soil extracts containing organic matter and giving them to the writer for analysis. The results were satisfactory in every case, and the method is now used in this laboratory.

Experiments were made to find out whether nitrate is formed by the oxidation of the organic matter by the permanganate. Soil extract 1931, containing organic matter but no nitrate or nitrite, was treated with permanganate. No nitrate was found after the treatment. A trace of nitrite from the air was found after evaporating the alkaline solution, but none was found in the acid solution before evaporation.

A liter of a colored soil extract was heated and acidified, permanganate was added in excess to the hot solution and the brown precipitate was filtered off. The filtrate was made alkaline with sodium carbonate, divided into two parts, and evaporated. In one part, nitrogen was determined by the Kjeldahl method, and in the other part by the Kjeldahl method modified to include nitrates. The same quantity of nitrogen was found in the two portions, showing that there had been no nitrate formation. This experiment was repeated with a pasture soil containing 50 per cent volatile matter, chiefly in the form of cow manure and vegetable mould. The result was the same, namely, there was no nitrate formation from the action of the oxidizing agent on the organic matter. It is therefore safe to use permanganate for the purification of soil extracts for the nitrate determination.

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NOTES ON PLANT DISEASES OCCURRING IN NORTH CAROLINA.

By F. L. STEVENS and J. G. HALL.

ALFALFA.

Leaf Spot (*Ascochyta medicaginis* Bres).—This disease was found in abundance and did considerable damage in fields in Wake County. It has not been reported in America before, and is a new parasite upon alfalfa.

APPLE.

Bitter Rot (*Gleosporium fructigenum* Berk).—This disease was reported from Buncombe, Haywood, Stokes and Wilkes counties. The amount of damage is estimated at from twenty to seventy-five per cent of the crop.

Black Rot (*Sphæropsis Malorum* Peck).—Specimens of this disease were received for determination and advice from Sampson County.

Black Rot Canker (*Sphæropsis Malorum* Peck).—Apple twigs were received from Paul Cable, of Greensboro, with a statement that his trees were very seriously affected, some of them killed. Microscopic examination revealed only the presence of *Sphæropsis Malorum,* but this in considerable abundance. Apple twigs affected with the Black Rot Canker were also received from Mr. Howard, Salemburg, with a statement that they were from a young orchard of one hundred and ninety trees, twenty-six of these trees being seriously affected with this canker, one dead, and four or five others nearly dead. Another package was from an older orchard of sixty trees, in which some three of the young trees were affected and four or five of the older trees.

The canker differed from any other canker which has come under our observation, the chief point being an intense black color over the bark, and the presence of abundant spore-bearing pustules. The diseased portion is usually divided from the healthy by a sharp, definite line, and the diseased portion stopping in growth before the healthy above and below it, is nearly always of smaller diameter, giving striking appearance of constriction. On cutting into the wood of the diseased region, it was found to be blackened, often to the center, and this blackening frequently extended a long distance, both above and below the cankered portion. Microscopic examination showed this blackening to be due to the presence of a black mycelium in the diseased tissue, this mycelium having all the characteristics of that of *Sphæropsis.* On some of the cankers *Sphæropsis* only was found; on other cankers, an ascomycetous fungus only, while in other instances both the Ascomycete and *Sphæropsis* were present.

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BLOTCH (*Phyllosticta*).[1]—For several years this disease has been noticed in many portions of the State, on apple twigs, forming small cankers. The fungus appears to be identical with that described as the "blotch," so abundant and destructive in Arkansas on the fruit and foliage of the apple. Strange to say, however, in North Carolina our attention was not called to this fungus affecting fruit and leaves until March 3, 1908. A letter was then received from M. L. Willard, of High Point, in which he states: "I wish to consult you about my apple trees. They look thrifty and bear well; about the middle of July they begin to shed some of their leaves; about the same time I discover little black specks on the apples. About the middle of August they begin shedding their leaves again, and by that time the black specks have grown till the apple is about decayed. By the middle of September the leaves are all off. By that time you hardly find an apple but what is decayed or partly decayed. The trees I am speaking of are the Red Limbertwig. I have in the same orchard some May apples and some harvest apples that mature well."

FIG. 1.—Apple Canker, Pyllosticta. At right, one year old twig showing several young cankers; at left, older twig showing more mature and rougher canker.

From this description it seems probable that this is an actual occurrence of the blotch in a very destructive form on the fruit in North Carolina.

CANKER (*Phyllosticta*).—The canker upon the bark of apple twigs has been under observation for several years. It usually begins upon the one year old twigs, where the canker first appears as yellowish, brown spots, in the central region of which are scattered very minute spore bearing pustules. As the canker becomes older, it encroaches upon the fresh bark around the original canker; the bark ruptures and a considerable portion becomes roughened. The spores from the pycnidia show the fungus to belong to the genus *Phoma* or the genus *Phyllosticta*.

[1]This is the species reported by some pathologists as P. ***solitaria*** E. and E.

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It is unquestionably the fungus called *Phyllosticta solitaria* by various authors, and which has been reported as being extensively destructive upon the fruit of the apple in several States, notably in Arkansas. It is noteworthy that so far as our observations go, this fungus, while widely distributed upon the twigs, does little or no damage upon the fruit itself here unless in exceptional cases.

Aside from finding this canker abundant in Wake County, specimens were also received from Madison and Henderson counties.

FIREBLIGHT (*Bacillus amylovorus* (Bur), De Toni).—This disease was noted in a very destructive form in nearly all of the counties visited on the Farmers' Institute trip. In many instances single trees were killed; in some instances, whole orchards. Specimens were received during the year from Iredell, Buncombe and Sampson counties.

HYPOCHNOSE.—This disease, not heretofore recognized in the United States, was collected in the following places in North Carolina: Horseshoe, Addie, Franklin, Hayesville, Marshall, Murphy, Robbinsville, Sylva, Bryson City, Fatima, Newton, Eufola and Mt. Airy. It produces a rotting of the leaves, in which condition they have a tendency to droop and mat together. These diseased leaves are accompanied by brown, fibrous or globular sclerotial formation upon the twigs.

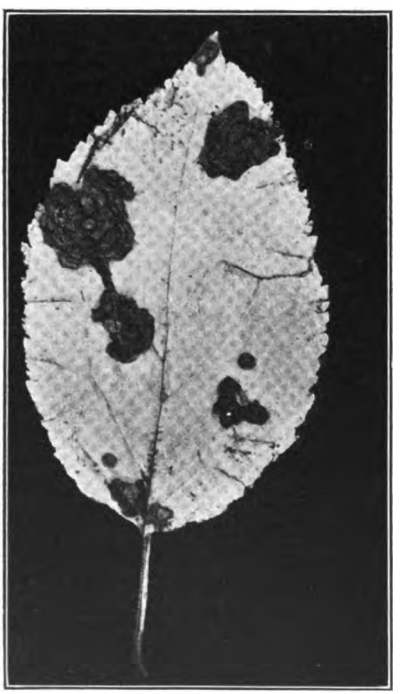

FIG. 2.—Apple Leaf Spot, in late stage of development, showing concentric rings.

LEAF SPOT (*Phyllosticta, sp.*).—Leaf spots, consisting of brown dead tissue, occur in all portions of the State. It is customary to attribute these spots to a species of *Phyllosticta*. Whether they are all due to the same species, or indeed whether they are all due to *Phyllosticta* at all or not is an open question. In any even, the leaf spot abounds in North Carolina wherever the apple is grown, being, in general, very much worse in the mountains than in the more eastern sections of the State. The leaf spot consists of circular regions of dead tissue, sharply bounded from the healthy tissue. In the older spots there is a characteristic concentric arrangement of irregular circles. This disease is al-

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most entirely held in check by proper spraying. Specimens were received from the following counties: Rowan, Guilford, Davidson, Vance, McDowell, Greene, Burke, Iredell, Wake, Henderson and Surry.

Moniliose (*Monilia fructigena* Pers.).—This fungus was found upon apples sent to the Station by B. F. Sparger, of Mount Airy, many of the fruits submitted by him developing well marked, characteristic cases of *Monilia* rot after remaining in the laboratory for a few days. The fungus, from measurements and appearance, agrees entirely with *Monilia fructigena*. This is the first record of the occurrence of this disease in North Carolina, although it has long been seriously destructive in Europe. It has been reported from the following States: Arkansas, Nebraska, New Mexico, Virginia, and West Virginia. The disease was particularly abundant in the portion of the orchard adjacent to plum orchards, where the Japanese and Abundance plums had been very seriously affected with this fungus the preceding spring.

Rust (*Gymnosporangium, sp.*).—The apple rust is much worse in the Piedmont and the coastal section than in the mountains. It was seen in an especially destructive form this year in Brunswick and Durham counties. Specimens were submitted this year from the following counties: Franklin, Wake, Halifax, McDowell, Burke, Rowan, Iredell, Cabarrus, Mecklenburg and Surry. Its winter stage upon the cedar tree is a familiar sight in spring, throughout the eastern and central portions of the State, most of the cedar trees being thickly hung with cedar balls, protruding from which are the well-known gelatinous honey-colored horns. This disease is said to be more severe upon the Tawny and the Horse apples.

Scab (*Venturia inæqualis* (Cke.), Wint).—Specimens of this disease upon the fruit and also upon the leaves where it appears as black, sooty spots, were received this year for determination from Buncombe, Iredell and Moore counties.

BEANS.

Anthracnose (*Colletotrichum Lindemuthianum* (Sac. & Magn.), Bri. & Cav.).—This anthracnose occurred in considerable quantity on the College farm and other places in Wake county. Reports were received from Montgomery and Iredell counties. One report says that 90 per cent of the pods were diseased. In October a large quantity of diseased pods was gathered, brought to the laboratory and dried, for the purpose of study.

Rust (*Uromyces appendiculatus* (P) Lav.) was collected in Davidson and Catawba counties.

CANTALOUPES.

Downy Mildew (*Peronospora Cubensis* B. & C.).—This disease is identical with the mildew of the cucumber and may be expected anywhere that the cucumber disease is found.

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NEMATODES (*Heterodera radicicola* (Greef), Mul.).—Specimens of cantaloupes very badly galled by nematodes were received in September from R. A. Parker, Duplin County. The roots were galled from end to end, the galls being exceedingly large and abundant. Referring to the injury done, he says: "We planted five acres. They came up and grew off at first better than my neighbor's in an adjoining field, but about the time they began to run they began to turn yellow, and lots of them finally died. A good many that did not die did not produce any fruit. We gathered 500 crates from the five acres and my neighbor in adjoining field gathered 600 crates from three acres." Specimens of roots from the "adjoining field," mentioned above, proved to be entirely free from nematodes, and it is probable that the discrepancy in yield between these two fields is to be attributed to these nematodes. The disease is apparently very widely distributed through the State, often doing much damage.

CARNATION.

ROOT KNOT (*Heterodera radicicola* (Greef), Mul.).—Roots affected with nematode galls were sent to the Station for determination from Wake county.

CAULIFLOWER.

BLACK ROT (*Pseudomonas campestris* (Pam), Smith).—Specimens of cauliflower thickly covered with densely black spots were observed upon the open market in Raleigh. The disease was exceedingly conspicuous, owing to the intense black spots upon the white background furnished by the healthy portions of the cauliflower. Upon examination it was found that the black spots were due to bacteria, which had all the appearance of being the usual form causing the black rot of the cabbage. The vascular bundles, leading from the spots toward the center of the head,

FIG. 8.—Cauliflower Black Rot (Pseudomonas campestris). The blackened spots are caused by this bacterial rot.

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were blackened in a manner characteristic of vascular bundles of plants affected with black rot, and it seems clear that this disease is identical with the cabbage black rot.

From the appearance of the disease it seems certain that the infection was from the surface and the disease was progressing inward. Upon inquiry, it was found that the diseased cauliflower was shipped from Washington, N. C., and it was impossible to ascertain where they were grown. The occurrence of this disease in this fashion is of much interest to North Carolinians, since it shows one manner in which it may gain access into and distribution through the State.

CELERY.

Leaf Spot (*Septoria petroselina* Desm. var. *apii* Br. & Cav.).—This disease made its appearance in a very destructive form in gardens in Wake county this year, causing the loss of the whole crop in many instances. The leaves turn yellow, and then, upon closer examination, are found to have black dots, pycnidia, upon them. This disease may be held in check by spraying with Bordeaux mixture.

CHRYSANTHEMUM.

Leaf Spot (*Septoria Chrysanthemi* Cav.).—This diseased specimen was sent in for determination from Cumberland county.

CHERRY.

Shot Hole Disease (*Cylindrosporium padi* Karst).—This disease abounds in all sections of the State. It was collected particularly this year in Brunswick, Wake and Halifax counties, and specimens were sent in for determination from Guilford county.

COLLARDS.

Sclerotinose (*Sclerotina Libertiana* Fckl.).—Collards affected with this disease were collected in Wake county by B. B. Higgins.

COTTON.

Anthracnose (*Colletotrichum gossypii* South).—Cotton anthracnose has been particularly abundant this year. Specimens were received from Cleveland, Wake, Craven, Montgomery, Beaufort, Iredell counties, and letters of inquiry concerning it were received from Richmond and Scotland counties. In many instances people writing concerning cotton anthracnose in their fields this year stated that the only portions affected upon their plantations were fields which were planted with seed from some distant source, it being frequently stated that the seed producing the anthracnosed crop came from Georgia. The frequency with which such observations were made agrees well with the generally accepted idea that the fungus causing the anthracnose may be carried from one crop to the next upon the seed, and it serves to emphasize the importance of avoiding seed which

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comes from infected fields, and of knowing the character of the field from which seed does come, so that the grower may be certain that the seed which he has purchased came from a healthy, not from a sick field.

Aerolate Mildew (*Ramularia areola* Atk.).—The frosty mildew affects the leaves, producing small, angular spots, which are first pale green, then turning light yellow and pale brown. Upon the under side of the leaf, in the early stages of this disease, small spots covered with a frosty white growth are seen. The disease is seen in most cotton fields examined, but usually it is of no very great importance, although in some instances, if the leaves become much spotted, the whole leaf will become weakened, will turn yellow and fall off. In this way the disease sometimes becomes to some degree serious.

Bacterial Disease (*Bacillus Malvacearum* Erw. Smith).—Specimens of this disease were collected in Wake county. The disease was not noticeable in particularly destructive form. In seriousness it seems to be about equal to the frosty mildew, which in many ways it very closely resembles in general appearance.

Wilt (*Neocosmospora vasinfecta* (Atk.), Erw. Smith).—Several complaints of cotton wilt from isolated sections of the State were received this year. This disease is undoubtedly widespread throughout the cotton section of the State, although in many instances the territory of the individual fields which are invaded is not very large. The disease, however, is constantly spreading, and is one which should be carefully guarded against by cotton growers.

COWPEA.

Leaf Blight (*Cercospora Dolichi* E. and E.).—This leaf blight prevails nearly everywhere the cowpea grows, producing a spot which, viewed from below, is angular and is of a uniform ashen, dirty color. The spot is surrounded by a region of the leaf, which is pale yellow in color. Many spots upon the leaf result in its premature death and cause it to fall off.

Leaf Spot (*Amerosporium œconomicum* E. & T.).—This disease is readily distinguished from the last by the fact that the spots are circular and are studded all over with little black specks smaller than the ordinary pin hole. The spots of this are also of shining whiteness, and in this character are quite readily distinguished from the Cercospora spot. The disease is often abundant, but is usually not so serious as is the Cercospora.

Root Knot (*Heterodera radicicola* (Greef), Mul.).—Plants badly affected with root knot were collected in Wake county. This disease may be overcome by using the Iron variety of cowpeas, which is resistant to the disease.

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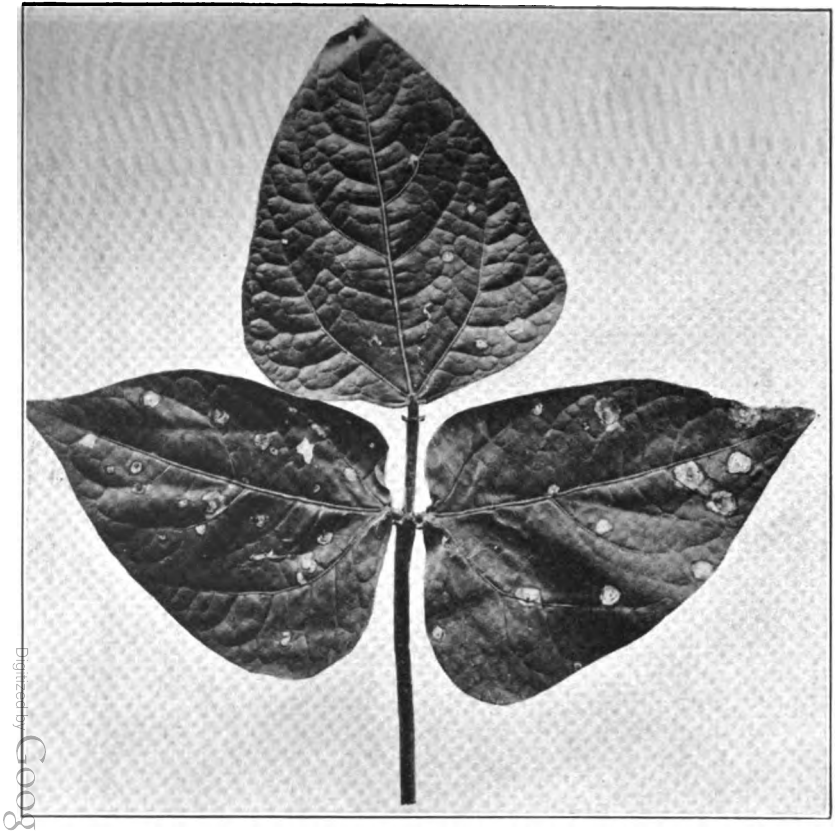

FIG. 4.—Cowpea, Leaf Spot (Amerosporium).

FIG. 5.—Cowpea Leaf Spot (Amerosporium). Abundant spore bearing pustules scattered throughout the circular spot (enlarged four diameters).

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CUCUMBER.

Downy Mildew (*Peronospora Cubensis* B. & C.).—The downy mildew, which has proved so destructive to cucumbers in other States, in South Carolina so injurious as to almost destroy the cucumber industry in certain sections, has begun to make its appearance abundantly in North Carolina. Specimens were collected this summer in Wake, Wayne, Cabarrus and Alamance counties. This disease is recognized by the yellowish angular spots as shown from the upper side of the leaf. The spots enlarge until the whole leaf is involved, and it soon droops and dies. This disease has given way in other States to careful spraying, and would probably do so here.

DEWBERRIES.

Septoria rubi West.—Specimens were received for determination from Moore county.

GRAPES.

Black Rot (*Guignardia bidwillii* (Ell.), V. & R.).—This disease is abundant throughout all portions of the State and upon all varieties of bunch grapes. The scuppernong is almost immune and is only rarely found with a single spot of black rot. Specimens of black rot on the bunch grape were received from Buncombe, Halifax, Pender, Burke and Moore counties.

GRASS.

Myxomycete (*Physarum cinercum* (Batsch), Pers.).—In several instances grass has been known to be affected with a species of Myxomycete. The fungus causing this damage has been determined by McBride as *Physarum cinereum*. The damage begins in the diseased spots in the lawn or field, in which the grass plants become totally covered with the fruiting organs of the fungus, so that when viewed from a distance of a few feet nothing but a black spot is seen, the grass being entirely hidden by the slime mold growing over it. The spot rapidly enlarges, often becoming several yards in area. This disease was noted a year ago at Raleigh, and it became so serious at Waynesville and Oxford that specimens were sent in for determination and advice this year. It may be mentioned that the same fungus has also been noticed as a parasite on grass in Montgomery county, Penn.[1]

LETTUCE.

Sclerotinose (*Sclerotina Libertiana* Fckl.).—This fungus made its appearance upon the lettuce beds of West Raleigh, where it was first seen by B. B. Higgins on November 26. The sick plants collected and brought into the laboratory developed the characteristic symptoms of sclerotinose. There is no record that this fungus existed in this place before, and its occurrence is noteworthy as a possible

[1] A Grass-killing Slime Mould. By John W. Harshberger, Ph D., Proc. Am. Phil. Soc. XLV, Nov. 3, 1906.

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indication that the fungus was already in the soil, subsisting naturally on some other host plant.

PEACH AND PLUM.

Cornularia Persicæ (Schw.), Sacc.—This peculiar fungus was noted in every portion of the State where examination for it was made. Specimens were collected in abundance in Wake and Lenoir counties. It probably does little or no damage to the trees.

Peach Curl (*Exoascus deformus* (Berk.), Fckl.).—Specimens were received for determination from Granville county. This disease is almost completely controlled by spraying with Bordeaux mixture before the buds open.

PEAR.

Black Rot Canker (*Sphæropsis malorum* Pk.).—Specimens of badly cankered pear limbs were received from S. C. Godwin, Fayetteville, on December 13. Microscopic examination showed the presence of mycelium and fruiting pycnidia of *Sphæropsis* in great abundance. Godwin writes: "Some of my trees are dead and all except one are so badly affected that they can hardly survive."

This is the first complaint that we have had of *Sphæropsis* as a very destructive canker-producing fungus on pears in this State, although the fungus is exceedingly common upon the apple. Specimens showing injury from this disease were also received from Cumberland and Alexander counties.

Blight (*Bacillus amylovorous* (Burr.), De Toni).—This blight was even more destructive than the apple blight, as is usually the case, and is present in the State practically everywhere that pears are grown, and upon nearly all varieties. One variety, known as the Florida Sand Pear, raised by N. W. Herring, LaGrange, N. C., possesses a very high degree of resistance to this disease. On inspection last year this variety was seen to pass entirely unscathed, while adjoining Keiffers were very seriously affected. Specimens were received from Mecklenburg, Jackson, Randolph and Moore, and inquiries from Catawba, Franklin, Richmond and Vance counties.

Leaf Spot (*Septoria piricola* Desm.).—Pear trees badly infected with the leaf spot were noted in Brunswick county, about twenty miles from Wilmington, in the summer of 1907. The trees were so badly infested that every leaf bore one or more spots, while many of the leaves had a dozen or more each. The spot was exceedingly characteristic, being of a pale, ashen color, with a very definitely limited border. It was angular in outline and limited by the veins. The spots were small, ranging from two or three to six or eight millimeters in diameter, and usually bore one, two or three small black specks, which upon microscopic examination proved to be pycnidia. In section, the pycnidia are seen to be deep-seated, only the mouth

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projecting above the epidermis. In appearance they agreed exceedingly well with the drawing given by Atkinson in Bulletin 145 of the Cornell Experiment Station. The cavity of the pycnidium was filled with rather long, curved, crooked or crescent-shaped spores, which exhibited a strong tendency to adhere together in compact

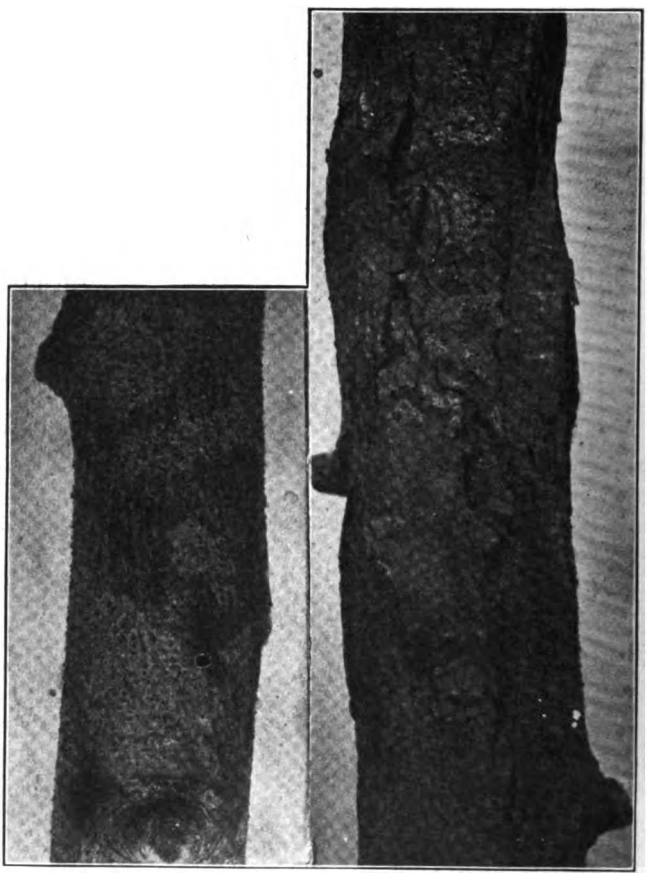

FIG. 6.—Pear Canker (Sphæropsis). At right, the cracked bark of cankered portion. Minute spore bearing pustules are apparent in certain portions. At left, bark thickly beset with spore-bearing pustules.

masses. These spores have the characteristic shape, form and septation of *Septoria*. Most of them were continuous, though very rarely spores with one, or occasionally two septa were seen. In striking distinction, however, from the usual *Septoria*, and from the genus as defined, these spores were dark in color, agreeing thereby with the genus *Hendersonia*. The possession of dark spores seems, however, to be permitted to *Septoria* in the species *Septoria piricola* Desm., which is, in all probability, the species in hand.

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POTATO, IRISH.

SCAB.—The prevalence of this disease in the State is not well known. It is probably abundant. Specimens were collected this year by B. B. Higgins at Newton and Eufola.

POTATO, SWEET.

DRY ROT.—A rot of the sweet potato, consisting of sunken, somewhat shriveled, dried, brownish areas, has been repeatedly reported to the Station this year for diagnosis and advice. The accompanying illustration shows the appearance of the potato, both from surface view and in section. It is noticed that the rot penerates to considerable depth into the potato.

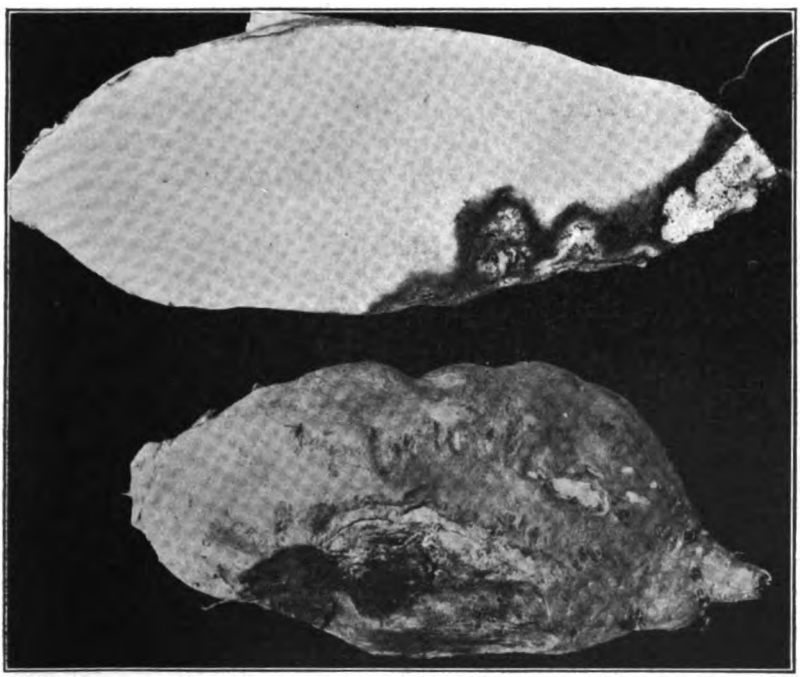

FIG. 7.—Sweet Potato Dry Rot. Below is shown shrunken, shrivelled, brownish, diseased region; above is shown a longitudinal section, and the depth to which the disease penetrates.

Observations in the laboratory show that the diseased spots enlarge slowly, as time passes, yet with sufficient rapidity to cause the spot to change from a small one to a very large one in the interim between housing and springtime.

In culture this condition of disease always gave a *Fusarium,* which was accompanied by a *Nectria,* apparently identical with *Nectria Ipomoeæ,* mentioned by Halstead[1] as causing a rot of the sweet po-

[1] N. J. Agr. Exp. Sta. Rept., 1891, p. 281.

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tato. While the fungus seems to be the same one noted by Halstead, we do not feel sure that the rot with which we are dealing is the disease which he studied.

Specimens of potatoes affected with this disease were received from L. C. Ellington, Madison county, January 8, 1908; J. M. Garrison, Gaston county, and A. B. Cooper, Beaufort county.

The relation of the fungus to the disease is still the subject of study here. The indications at present are that this is a soil disease and that it is not advisable to raise potatoes successively on fields where this disease has shown itself.

Leaf Spot (*Phyllosticta bataticola* Ell. & Mart.).—The *Phyllosticta* spot is present in sweet potato fields generally, but it is probably not of serious import.

White Smut (*Albugo Ipomoeæ panduranæ* (Schw.).—This is found frequently, though it is not exceedingly common upon the sweet potato. The injury from it is trifling.

QUINCE.

Rust (*Gymnosporangium*).—This rust, the same that affects the apple, winters likewise upon the cedar tree. Specimens were received for determination from Moore county.

ROSE.

Black Spot (*Actinonema rosæ* (Lib.), Fr.).—Specimens were received from Warren county.

Blossom Blight.—Attention has been repeatedly called to a disease of roses, which appears in very destructive form. The disease manifests itself in the failure of the buds to open. The buds mature in apparently normal condition, until they become about one inch long, the outer petals then show signs of wrinkling, the first indication of the disease. The buds continue to expand somewhat, the outer petals begin to turn yellow or straw-colored, and soon all development ceases. In some instances the buds partially open, but as a rule they do not attain a size of more than 1½ inches, and the petals do not really open at all. In most instances where the disease is noted it occurs on several buds on the bush. The character of the disease in single buds is shown in Fig. 9.

In a short time after the disease becomes evident in the bud, all development ceases, petals die, and the line of absission between the pedicil and the stem becomes marked, and the flower may be easily separated from its stem at this point. The whole bud soon dries up, its stem, down to the line of absission, likewise shrivels and dries, and the occurrence of the disease remains conspicuous by the presence of dry, straw-colored, dead buds upon the bush.

The disease is known to recur season after season on the same bush, while other bushes in the immediate vicinity, growing in the same soil and climate, are free from infection.

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Close microscopic examination failed to reveal the association of any fungi or bacteria with this disease. It seems, therefore, that it must be, for the present, classed as a "physiological disorder," brought about by some unknown cause. It is possible that it is hereditary and that avoidance of stock subject to this disease may lead to the removal of the difficulty.

FIG. 8.—Rosebud Blight, showing destructive nature of the disease on individual bushes; every bud is diseased.

FIG 9.—Rosebud Blight, showing withered bud and dry, dead condition of the peduncles.

MILDEW (*Sphærotheca pannosa* (Wallr.), Lev.).—This disease is one concerning which probably more queries have been received than regarding any other plant disease of the State. The Mildew makes its appearance early in the spring, almost as soon as the leaves come out, as a white, dusty powder over the surface of the leaves, stems and buds.

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The leaves so affected fail to develop properly, roll or curl up, the buds fail to open, and the growth of the plant is stunted. The appearance of such a diseased twig, as contrasted with the healthy twig, is well illustrated in Fig. 10. Concerning this disease this year, queries and specimens have been received from the following counties: Halifax, Cleveland, Durham, Warren, Iredell and Granville counties. Queries without specimens were received from Chowan county.

The rose mildew may be readily prevented or held in check by use of the various spraying mixtures. Probably the Bordeaux mixture

b a

FIG 10.—Rose Mildew: (a) healthy twig; (b) badly diseased twig.

is most to be recommended, unless the bush is so located that the use of the Bordeaux mixture would be undesirable, such as would be the case, for example, if the rose bush grows near a white house in such position that the Bordeaux would spot the house in an unsightly way. In such event, either liver of sulphur, one ounce in three gallons of water, or the ammoniacal copper carbonate may be substituted.

SORGHUM.

SMUT (*Sphacelotheca sorghi* (Link), Clint.).—A smut attacking the flowers and fruit, but not the stalk or leaves, was found in Wake county, but not in such quantities as to be of any serious damage.

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SQUASH.

(*Fusarium*, sp.).—Garden squash were seriously diseased in some instances, the vines appearing stunted, pale, and later dying. Upon miscropic examination, the vascular bundles were seen to be invaded by a fungus, which proved to be a species of *Fusarium*. The disease had all the characteristics of the ordinary wilt and was apparently caused by this fungus, which is one of the most common of the wilt-producing fungi. Whether the fungus be identical with that causing the wilt of cotton, melons, etc., was not determined, though no differences were noted.

SYCAMORE.

Powdery Mildew.—A powdery mildew has been noticed affecting the leaves of the sycamore seriously in early spring. Leaves are attacked long before they reach the mature form and structure, presenting very much the appearance of frost injury. The affected spots are blighted, fail to grow, turn dark in color. Owing to their failure to grow, the leaf becomes wrinkled, curled, and distorted. Examination of the affected spots shows them to be densely overgrown with the conidial stage of a powdery mildew. While no mature fruiting organs have been found, and it is impossible to make a complete determination of the fungus in its conidial stage, it agrees entirely with the description of *Microsphæra Alni*, which is reported as growing upon this host. The fungus is especially noteworthy from its attack early in the season upon leaves before they have completed their development.

TOBACCO.

Frog Eye (*Cercospora Nicotianæ* E. and E.).—Specimens were collected in tobacco barns at Greenville. The disease is probably generally prevalent.

Granville Tobacco Wilt.—This disease, hitherto unknown in literature outside of Granville county, was noted this year in Durham and Vance counties, and specimens, which seemed almost certainly to be this disease, were received from Quincy, Fla., where, says Shamel, "they are doing immense damage."

At Graystone, N. C., July 22, on the farm of James A. Tunstall, Ashe county, two small fields were noted where the wilt occurred. In one instance, out of six hundred plants counted, two hundred showed the typical disease, and it was apparent that about the same percentage prevailed throughout the field. Mr. Tunstall stated that he had known this disease in his tobacco for more than twenty-five years, and has been obliged to abandon a great deal of his tobacco land on account of its occurrence. According to his experience, the land affected with the wilt, left without tobacco for ten years, is still diseased, and if planted again at the end of that time, with tobacco, results in the loss of a large percentage of the crop.

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One farmer in the neighborhood lost his entire crop through this disease. There came under our personal observation one field of which it was stated that tobacco had not been planted on that field for at least twenty-five years, the field, however, was very badly wilted.

Root Knot (*Heterodera radicicola* (Greef), Mul.).—Many complaints were received concerning the root galls upon tobacco; notably from Whiteville and Washington. These galls are caused by minute worms or nematodes similar to the vinegar eel. These worms abound in the soil and from it enter the roots of the plants and cause the gall to develop. In many instances they do not seem to cause serious loss, but in other instances they are very destructive to the crop. The only remedy is to so rotate the crops as to avoid planting susceptible crops upon soil bearing nematodes.

There is always a possibility of finding tobacco plants which possess a resistance to the worms. If such plants are noticed, seed from them should be saved with great care with the hope of building up a disease-resistant variety.

TOMATO.

Blight (*Bacillus Solanacearum* Erw. Smith).—This bacterial disease of the soil which causes a dying of all tomatoes placed in it, unifortunately claims many fields of the State, and it is constantly spreading into new territory. It was noted in its usual abundance this year.

Blossom End Rot (*Fusarium Solani* (Mart.), Saac.).—Specimens were received for determination from Pamlico county.

Leaf Spot (*Septoria Lycopersici* Speg.).—The *Septoria* is to be distinguished from the blight by the fact that the leaves when first infected are diseased in spots only, whereas, in the blight the leaf is not spotted, but droops and dies as a whole. The leaf spot usually affects the lower older leaves first. As the spots enlarge, encroaching upon the whole leaf, the leaf dies. Often the disease progresses so fast that the whole plant soon becomes involved. This disease may be controlled by spraying with the Bordeaux mixture.

VETCH.

Downy Mildew (*Peronospora viciæ* (B.), DeBy.).—This disease appeared upon cultivated vetch in Wake county this spring and did a great deal of damage. The plants affected did not develop normally, were much smaller, weaker and paler than the neighboring ones. Upon close examination the under side of the leaves was found to be covered with the fine down of *Peronospora*.

WATERMELON.

Wilt (*Neocosmospora vasinfecta var nivea* Erw. Smith).—Inquiries concerning this were received from Vance county.

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NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

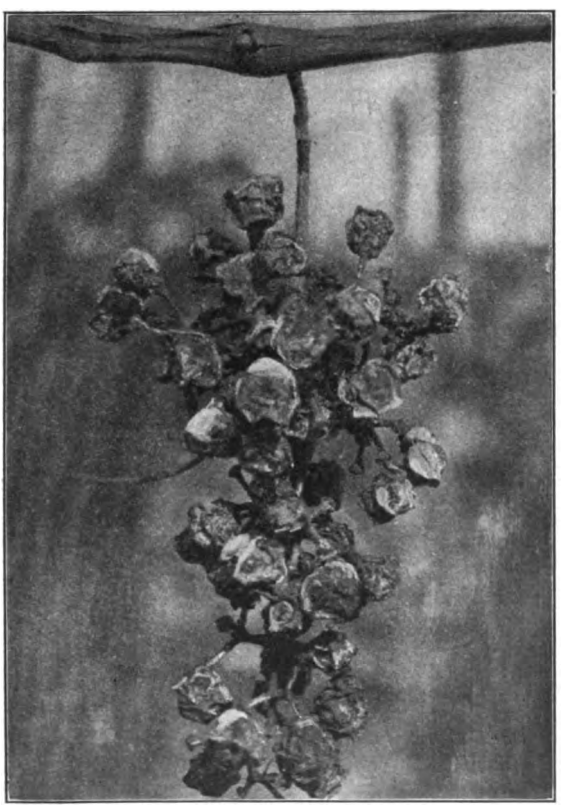
C. B. WILLIAMS, Director.

PRESS BULLETIN No. 17.—FEBRUARY 15, 1908.

THE GRAPE BLACK ROT.

This disease prevails in all parts of North Carolina. In most sections of the State it is so bad that the grape crop is practically ruined unless proper measures be taken to prevent the disease.

The black rot is easily recognized from the accompanying illustration showing its most conspicuous characters, blackening, drying



and final shrivelling of the grapes in the clusters. Often all of them shrivel and dry in this way. Though the disease is seldom noticed until the grape is badly shrivelled, it may be seen earlier as a brown or black spot on the berry. Before its appearance upon the fruit at

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One farmer in the neighborhood lost his entire crop through this disease. There came under our personal observation one field of which it was stated that tobacco had not been planted on that field for at least twenty-five years, the field, however, was very badly wilted.

Root Knot (*Heterodera radicicola* (Greef), Mul.).—Many complaints were received concerning the root galls upon tobacco; notably from Whiteville and Washington. These galls are caused by minute worms or nematodes similar to the vinegar eel. These worms abound in the soil and from it enter the roots of the plants and cause the gall to develop. In many instances they do not seem to cause serious loss, but in other instances they are very destructive to the crop. The only remedy is to so rotate the crops as to avoid planting susceptible crops upon soil bearing nematodes.

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all it may be found as brown spots, one-eighth to one-half an inch in diameter, on the leaves or twigs. Very close examination of the diseased spots on twigs, leaves or fruit, reveals the presence of very small pustules in great numbers.

These pustules are the fruiting bodies of the fungus which is the cause of the black rot, and from these pustules issue immense numbers of spores, which serve to spread the disease.

This disease can be prevented. If you saw black rot on your grapes last year it will almost certainly be there again this year, unless you take steps to prevent it. Prevention is simple and sure. It consists in spraying your vines with the Bordeaux mixture, consisting of six pounds of bluestone, four pounds of lime and fifty gallons of water. The first application, killing the spores that are wintering on the bark and trellis, should be made before the buds open; the second, immediately before the blossoms appear; the third, just after blossoming; the fourth and fifth at intervals of ten to fourteen days thereafter.

The cost of six sprayings for an acre of grapes is about fifteen dollars, including material and labor. The grapes saved will in value far exceed this cost.

Now is the time of year to get your spray pump ready if you have one; to buy one if you need to; to prepare for the spraying needed during the coming spring.

If you need further information regarding spraying mixtures, how to prepare them, spraying pumps, where to buy them, and what crops and when to spray, write to the North Carolina Agricultural Experiment Station, West Raleigh, N. C., for Bulletin 193, "Spraying Mixtures and Machinery, When and How to Spray."

The following Bulletins of interest to fruit growers may be secured upon application:

Bulletin 184. Garden and Orchard Fruits, their Culture and Marketing.

Bulletin 185. Black Rot of the Grape in North Carolina and Its Treatment.

Bulletin 186. Insect and Fungous Enemies of the Peach, Plum. Cherry, Fig and Persimmon.

Bulletin 187. Grapes and Small Fruits.

F. L. STEVENS, *Biologist.*

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Bulletin 197 MAY, 1908

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND

MECHANIC ARTS

WEST RALEIGH

SOME INSECT ENEMIES OF GARDEN CROPS

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THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

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A. F. BOWEN.....Bursar
C. P. FRANKLIN.....Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

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SOME INSECT ENEMIES OF GARDEN CROPS

CONTAINING PRACTICAL INFORMATION CONCERNING THE HABITS AND LIFE HISTORIES OF CERTAIN INSECTS, WITH REMEDIAL SUGGESTIONS

By R. I. SMITH, Entomologist

Without the home garden the farm is incomplete. Even the town or city home with its small area of land should possess a garden in which many vegetables may be grown to help supply the table, and reduce the market and grocery bills during both summer and winter. It often happens that the pleasure and profit derivable from the possession of a garden are both greatly diminished by the insects that prey upon the various vegetables, and sometimes entirely destroy them. Far too many gardens are carefully prepared and planted and afterwards allowed to become food for various insects, mainly through ignorance on the part of the gardener of the methods by which they might be controlled. For the person who aims to sell a part of his garden products a knowledge of insects and their control is especially necessary. The question of profit or loss may depend on the suppression or non-suppression of these pests.

It is only too true that some insects are difficult or almost impossible to suppress, but the great majority are within man's control when the proper remedial and preventive measures are applied. An illustration of well known and fairly easily preventable insect injury, occurring annually, is that of the Colorado Potato Beetle, which is perhaps one of the most common. The writer has frequently met with farmers, and small garden owners, who relied solely upon hand picking for the suppression of potato beetles, and frequently even this unsatisfactory method was delayed until the plants were nearly destroyed. How much time, labor, and expense, to say nothing of actual loss, such people might have saved by dusting the potato plants with dry Paris-green mixture, or by using the same poison as a liquid spray. This method of fighting the potato beetle and similar simple, reliable remedies for other insects are discussed in subsequent pages.

Numerous illustrations are inserted to assist the reader in recognizing the insects mentioned and as an aid in understanding their life history and habits. Without some knowledge of these facts insects can not generally be fought intelligently.

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In these pages no attempt has been made to include all the various insect enemies of the crops mentioned, but such only as may appear every year and cause more or less damage unless fought successfully. *"To be forewarned is to be forearmed,"* should be the maxim of every gardener. A knowledge of the life history and habits of insects aids one in adopting more successful preventive measures against these enemies.

Life History and Development of Insects.

The habits of insects constitutes a very interesting and broad field for study and investigation. Without some knowledge of the development, i. e., the life history of our principal injurious insects, we would be poorly equipped to conduct a warfare against them. It is not to be expected, nor is it necessary, that every gardener should know all about the changes undergone by these interesting insects, but there are a few principles governing their growth and habits that every person may readily remember. One of these is the *development,* or the changes that an insect undergoes during its life, and another is the *feeding habits* of all the various forms. These two principles, it will be found, are closely related, for certain insects, while in the young, immature stage, secure food by biting and chewing, like caterpillars; while the adult or parent of the same insect may take its food in an entirely different manner, for example, moths and butterflies. Grasshoppers, on the other hand, *always* chew their food, and in order to illustrate two forms of Insect Development, we will compare their growth with that of the Green Cabbage Worm.

Incomplete Metamorphosis.—Grasshoppers undergo incomplete

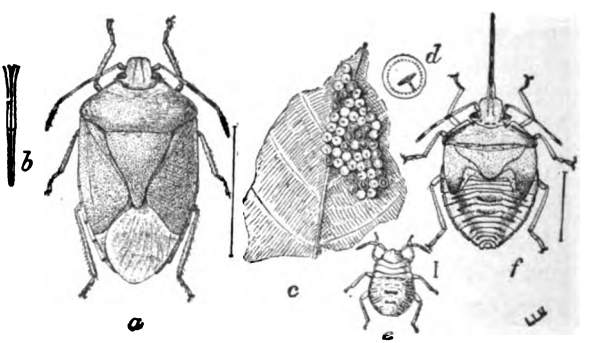

Fig. 1—Plant Bug, *Nezara hilaris: a*, mature bug; *c*, egg mass; *e*, young nymph; *f*, last stage of nymph—enlarged. (Chittenden, Farmers' Bul. 223, U. S. Dept. of Agr.)

metamorphosis or *direct development,* as there are only three distinct stages of growth, namely, *Egg, Nymph* (young), and *Adult.* Grasshopper eggs are deposited in masses in the ground, and from them, in due time, minute grasshoppers hatch, resembling the adult in

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general shape but somewhat clumsy in appearance and lacking wings. As they increase in size by successive molts, the wings commence to develop, first appearing as small, blunt pads, and finally becoming full grown. During this development the grasshopper always retains its general form and appearance. That is, a young grasshopper may always be recognized as such. Fig. 1 illustrates the similar growth of a plant bug *(Nezara hilaris)*, a sucking insect that sometimes punctures and injures cotton bolls.

Complete Metamorphosis.—Cabbage worms have a markedly different life history from the grasshopper, as they pass through four distinct stages, namely, *Egg, Larva* (worm), *Pupa* (quiescent stage) and *Adult.* This is called "complete metamorphosis" or *Indirect Development.* The adult or parent of the cabbage worm is a conspicuous white-winged butterfly (See p. 21) that flies about collard and cabbage fields on any bright, warm day. These deposit eggs that hatch into minute worms, which, when grown, change to pupæ corresponding to the familiar cocoon stage of many butterflies and moths. From the pupæ the perfect, fully developed butterflies emerge. To one wholly ignorant of the growth of insects these wonderful changes might seem impossible, but the statement may easily be verified by any one caring to make the experiment. The four stages of the Bean-leaf beetle showing "complete metamorphosis" are illustrated in Fig. 6, p. 15.

A few common garden insects have direct development, the young resembling the adult, such as plant lice, terrapin bugs, squash bugs, plant bugs and grasshoppers, but by far the great majority of them have indirect development, passing from the worm, grub, or caterpillar stage, to entirely different looking forms, such as beetles, moths and butterflies. These complete changes in appearance have at times given people erroneous and ridiculous ideas about certain insects. As an example, the writer once received a letter from a farmer, stating that the plant lice had been very abundant on his cantaloupes, but that they were then changing to beetles. These proved to be lady-bird beetles, predaceous parasites feeding on the lice, and of course an entirely different kind of insect. Besides, the beetles were directly responsible for the disappearance of the injurious lice.

Common Names of Immature Insects.

Entomologists classify insects into various orders, and have adopted a few common, accepted names for the young or immature stage of certain orders. For example, *Maggots* develop into two-winged flies (Order: Diptera); *Grubs* into hard-winged beetles (Order: Coleoptera); *Caterpillars* (both smooth and hairy) into moths or butterflies (Order: Lepidoptera). These common titles are frequently made use

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of by writers. Thus the reader may understand that when white grubs are mentioned it refers to the young of some beetles, generally May or June beetles. Similarly when caterpillars are mentioned the term always refers, or should refer, to the larval stage of moths or butterflies.

The term *larva* (plural spelled larvæ) may be used in referring to the young stage of all insects that have complete metamorphosis, such as beetles, bees, flies, moths, etc. The word *nymph* is used for the young of grasshoppers, terrapin bugs, squash bugs, etc., that resemble the adult insects.

Chewing and Sucking Insects.

More important in some respects than the knowledge of the life history of an insect, is that of its feeding habits. Every gardener should understand how insects get their food, whether by chewing or sucking, for without that knowledge he can not as readily understand why certain remedies are suggested against different insects. As already mentioned, the caterpillars, represented by cut-worms and cabbage worms, feed by chewing and actually devouring some portion of the host plant, while the parent moths or butterflies feed entirely differently. All beetles and their young feed by chewing. On the other hand, all plant lice, squash bugs, and most insects commonly known as "bugs," feed by means of long, slender beaks, which are used to pierce the plant tissue, and through which the plant juice is extracted.

Insects, therefore, may be divided into two great classes: first, *Chewing* or *Biting Insects*, and, second, *Sucking Insects*. The former includes all insects, whether in the immature or adult stage, that feed by biting and chewing; the latter includes a large class of insects that feed only by sucking the plant juices. A moment's thought will reveal the reason why it is that a poison spray, such as Paris-green mixture, that acts as an internal poison when swallowed with the food, would not kill an insect that sucks the sap. The latter make only a minute hole with the pointed beak and suck the sap from beneath the surface. How, then, may sucking insects be killed? Naturally by some substance that will kill by contact, having a corrosive, caustic, or suffocating effect. Kerosene emulsion, soap solutions, etc., are examples and are described more fully on pages 63 and 64.

This brief, simple statement of facts is inserted mainly as a suggestion to those readers who desire to learn something about insects. Of course arsenical poison sprays and contact sprays are useless against some insects. Borers and other forms that feed in protected places, even though they chew their food, can not be reached with

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arsenicals, neither can sucking insects be killed by a contact spray unless touched by the mixture. It is customary for people to think that all garden insects may be killed by a spray of some description, but this is an erroneous idea. White grubs in the soil feeding on the roots, boring insects hatching from eggs laid under the skin of plants, leaf-mining insects working between the two surfaces of a leaf, and others, can not readily be killed by any spray mixture. For these and various reasons it is necessary to understand the life history of insects; then the weakest, most vulnerable period in their career must be selected as the proper time to effect their eradication or suppression.

Nearly all insects succumb to poison fumes like carbon bi-sulphide and hydrocyanic acid gas, and insects in stored grains are best controlled by the fumigation method. With certain garden insects, cultural methods may be the only successful means of fighting them, and at times two or three methods may be combined against a single species.

INSECTS AFFECTING ASPARAGUS

Fortunately there are not many insects injurious to this valuable plant. There are, however, two asparagus beetles, both imported species, that may do considerable damage. Their injury is due to both adults and larvæ feeding on the young, tender, marketable shoots, rendering them unfit for sale, and also to defoliation of older plants. Since their habits and method of injury to asparagus are much the same they will be mentioned here together.

COMMON ASPARAGUS BEETLE *(Crioceris asparagi,* Linn.).
THE 12-SPOTTED ASPARAGUS BEETLE *(Crioceris 12-punctata,* Linn.).

DESCRIPTION AND LIFE HISTORY.

Beetles.—Are about one-fourth inch in length, both species being somewhat strikingly colored and marked. The common asparagus beetle, shown in Fig. 2, has the thorax or fore part of the body, reddish-yellow marked with two black spots. The wing covers are marked by a bluish-black stripe along the middle line where they meet, and lateral extensions of this main stripe extend toward the edges, which are orange colored. The intervening color is lemon-yellow. The underside of the body and the legs are usually shining black. The 12-spotted beetle is uniformly reddish in color, with twelve black spots on the wing covers (Fig 3). The body is broader than the common species. These beetles cause much damage by gnawing into the young marketable shoots, and later the beetles of the common species help to defoliate the plants, while the 12-spotted beetles feed mainly on the berries.

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FIG. 2.—Common Asparagus Beetle on asparagus: Showing eggs, larvæ and adult; asparagus top at right, showing eggs and injury. (Chittenden, Yearbook, 1896, U. S. Dept. of Agr.)

are assisted by the adult beetles. The larvæ, called *"grubs,"* may attain a size of one-fourth inch or slightly longer. They are soft bodied, yellowish or dark gray in color. The larval period varies, but is usually about twelve days, after which they drop to the ground, burrow down and change to pupæ in dirt-covered cocoons.

Hibernation.—The beetles pass the winter hidden about in any convenient shelter, under loose bark of trees, in fence corners, and like places, coming forth in early spring as the asparagus commences growth.

Eggs and Egg-Laying.—The eggs of both beetles are similar in shape, but those of the common species are placed on end, usually in rows, while the others are laid singly and flat against the plant. While the beetles may appear at about the same time, the 12-spotted beetles do not often commence to deposit eggs until a month has elapsed, while the common species commence quite early.

Larvæ and Feeding Habits.—The larvæ of the common asparagus beetle when first hatched do much damage by gnawing into the tender shoots, and in this work they

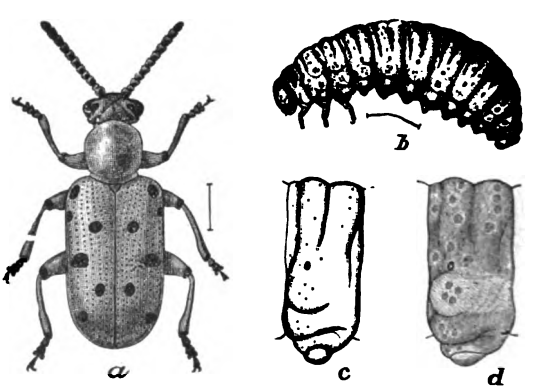

FIG. 3.—12-Spotted Asparagus Beetle: *a*, beetle; *b*, larva. (Chittenden, Yearbook, 1896, U. S. Dept. of Agr.)

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As already stated, the eggs of the 12-spotted beetle are deposited late and the larvæ feed on the berries, if present, causing them to drop before ripening. In appearance these larvæ do not differ materially from the ones just described, except for being reddish in color.

Generations.—The life cycle from egg to adult requires only about thirty days, hence there may be several broods each season. The beetles hibernate quite early in the fall.

REMEDIES AND PREVENTION.

Asparagus beetles should be controlled by preventive measures largely, although direct remedies are at times necessary. Commencing early in spring when the beetles first appear, the asparagus grower should aim to destroy all eggs deposited, before they hatch, and supplement this by poisoning the beetles on trap plants. The eggs of the common asparagus beetle are frequently laid in the bud of young shoots just as they appear, or on the stems of any plants in the field. Obviously all old plants, with the exception of a few left as trap plants, should be cut down, and new shoots cut out clean at least every three days. Beetles and larvæ on trap plants may be shaken into a pan of kerosene, and the plants may be dusted frequently with a mixture of lime dust and Paris green, using one pound of the poison in thirty pounds of air slaked lime. The lime dust alone is an effective remedy for the soft bodied larvæ, killing all that it touches, and the mixture acts as a poison to both larvæ and beetles.

Trap plants bearing eggs and larvæ should be cut out frequently—at least once a week, and new plants allowed to grow up in their place. Since the larvæ of the 12-spotted beetle feed mainly in the berries they can not well be poisoned; hence frequent destruction of plants bearing the eggs is advisable. Larvæ of the common species may be shaken from the plants on sunny days when the earth is hot, and many will die before getting back to the plants.

Arsenate of lead (See p. 61), as a liquid poison spray, may be used on fields that are allowed to grow during summer and fall.

INSECTS AFFECTING BEANS.

Bean plants are subject to injury from leaf eating insects from the time they appear above ground; the fruit may be damaged by boring caterpillars; the stored beans partially destroyed by weevils; the seed when planted is sometimes injured by ants and wireworms, and young plants severed by cut worms.

WIREWORMS (See under Insects Affecting Corn, p. 31).

CUTWORMS *(Larvæ of Night Flying Moths).*

To gardeners these pestiferous creatures are very familiar. Some, however, may not be acquainted with their life history, or the best

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remedial measures. The former is very interesting and indicates how the larvæ should be fought. When beans, and many other garden plants commence to appear in spring, they are cut off at night just above the surface of the soil by these pests. During the day the cutworms lie in shallow burrows in the soil or under any available cover, coming forth to feed only at night. There are a number of species, variously known as greasy, variegated, dark-sided, glassy, clandestine, etc., all having about the same habits, but differing in appearance.

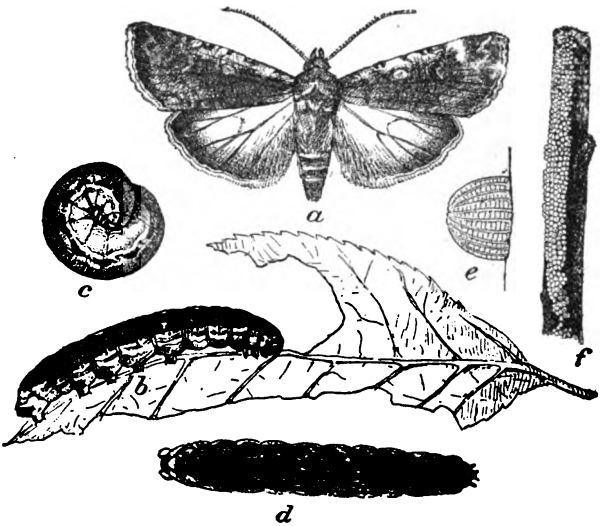

FIG. 4.—Variegated Cutworm, *Peridromia saucia: a*, adult moth; *b*, *c*, and *d*, larvæ (3 views); *e*, single egg much enlarged; *f*, egg mass on grass stalk. (Howard, Div. of Ento., U. S. Dept. of Agr.)

DESCRIPTION AND LIFE HISTORY.

Life History.—Noticeable damage by cutworms occurs mainly in spring when gardens are first started. The worms responsible for the damage are ones that pass the winter in hibernation, awaiting the advent of spring to issue forth in search of food. To appreciate the appetite displayed by cutworms one must understand their life history, which is as follows:

About June or July cutworms become fully grown. They then burrow into the earth, form silk-lined oval cocoons and transform therein to pupæ. About three weeks later the adult parent moths emerge and soon deposit eggs for the next brood. The eggs (Fig. 4, f) are placed on any succulent vegetation, grass or weeds, on which the larvæ, when hatched, feed and become about one-half grown before winter weather drives them into hibernation. The following

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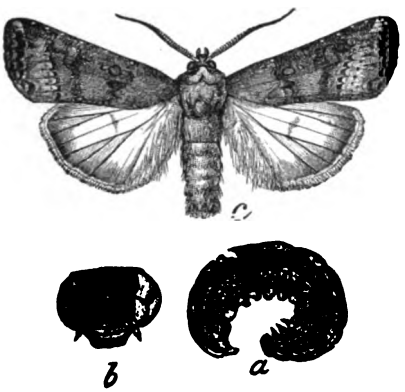

FIG. 5.—Black Cutworm, *Agrotis ypsilon:* Showing larva and adult moth. (Riley and Howard, Div. of Ent., U. S. Dept. of Agr.)

spring they awake with ravenous appetites after their long winter's fast, and naturally devour any green vegetation at hand.

Parent Moths.—The moths shown in Figs. 4 and 5 are of medium size and have wings, which expand one and one-half to two inches. The front wings are dark brown or gray, never conspicuous, but usually bearing a kidney-shaped spot of lighter color; hind wings always lighter than the fore wings. These moths hide during the day, but if disturbed fly with a quick, darting motion.

Larvæ.—All have naked bodies, varying in color from dirty green to gray and brown, but often distinctly marked with longitudinal dark stripes and dots. They have three pairs of true legs at the anterior (head) end and five pairs of fleshy pro-legs behind (Fig. 4, b). When disturbed they always curl up, as shown at Fig. 4, c.

Generations.—Only one generation occurs each year, and the greater portion of their life is passed in the larval stage.

REMEDIES AND PREVENTION.

Preventive measures are preferable to direct remedies, though the latter are fairly successful. Gardens that are in constant cultivation and that are kept free from weeds would not be greatly infested with cutworms, were it not for the ones that wander in from adjoining grass lands, but as this always occurs gardens are seldom exempt from them. The natural food of cutworms is grass, and for this reason sod land during the first year's cultivation is liable to be badly infested.

Cultural Methods.—Gardeners may determine with reasonable certainty what fields are most liable to be infected. Sod land, or grassy and weedy gardens may always be suspected. Such lands should be plowed deeply in fall or early winter to disturb the cutworms in their earthen hibernating cells. Some will be exposed as prey to fowls and birds and some may die from exposure to the winter weather. It has been stated also that the rains soaking into the loosely plowed land will drive some larvæ from their cells. Cross plowing to further disturb and expose the cutworms is certainly advisable.

Domestic fowls should be encouraged to follow the plows, as they will destroy great numbers of insects.

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Paper Bands.—In small gardens, plants like tomatoes, cabbages, egg-plants, etc., may be protected from cutworms by bands of stiff cardboard or tarred paper pressed into the soil surrounding the plants. They need not be over one and one-half inches above the soil, as cutworms seldom climb. Occasionally a species of climbing cutworm appears, which must be fought by poison sprays or poisoned bait. Vertical holes with smooth, hard sides made close by the plants, are said to be good traps, as the cutworms crawl into them, and are unable to get out.

Poisoned Bait.—This is no doubt the best remedy to be used against cutworms before the crops are planted, acting as a preventive measure, though it may be used later. To make the best use of poison bait, prepare the garden or field by raking off all vegetation a few days before the crop is planted or seeds come up. Leave the land a few days, which will result in making the cutworms hungry. Then apply a bait made as follows: With forty pounds of corn-meal mix one pound of Paris green or white arsenic; moisten with water to make a rather stiff mash, and sweeten with two quarts of common molasses. Apply this bait about sundown in little heaps at frequent intervals over the field. Repeat this application for two or three nights in succession. In this way, many cutworms will be poisoned, especially if the land is free from vegetation. The bait may be placed in heaps close by plants that should be protected, but the paper bands are more effective.

Another good poison bait is made by cutting some succulent clover and dipping it in a barrel of water containing one pound of Paris green. This may be used while fresh the same way as the corn-meal bait.

All poisoned baits must be used with caution, or not at all, if chickens are liable to get to it.

Bean Leaf Beetle *(Cerotoma trifurcata,* Forst).

Injury is caused by the adults eating round holes in the leaves of beans and cowpeas, while the larvæ feed on the roots or main stem just below the surface of the soil.

DESCRIPTION AND HABITS.

The beetles are about one-sixth inch in length, varying in color from yellowish to reddish with black marking as shown in Fig. 6. When abundant, the beetles may defoliate plants severely. They hibernate during winter and usually appear quite early in spring.

The larvæ are slender in form and whitish in color, and feed on the roots or stems in the manner stated above.

There may be two or three generations. According to Chittenden[1] the life cycle requires from six to nine weeks.

[1] Yearbook Dept. of Agr. 1898, p. 254.

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REMEDIES.

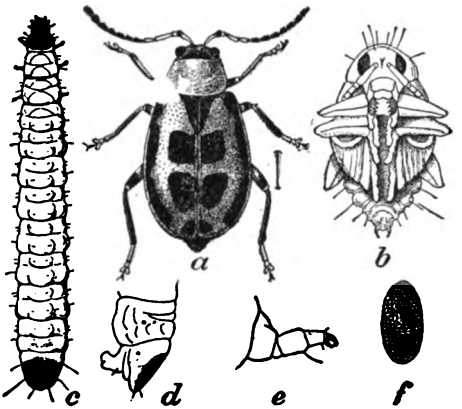

FIG. 6.—Bean Leaf-Beetle: *a*, adult beetle; *b*, pupa; *c*, larva; *f*, egg—*a*, *b*, *c* enlarged about six times, *f*, more enlarged. (Chittenden, Yearbook, 1898, U. S. Dept. of Agr.)

Spraying the plants with an arsenical poison, Paris green or arsenate of lead preferably mixed with Bordeaux mixture (See p. 61), is undoubtedly the best remedy. When the early appearing beetles are poisoned later spraying should not be necessary. String beans should not be poisoned when the pods are maturing. Further preventive measures against similar leaf-eating beetles are discussed on page 43 under cucumber beetles.

COMMON BEAN WEEVIL (*Bruchus obtectus*, Say).

The common bean weevil, *Bruchus obtectus*, Fig. 7, as well as other species of *Bruchus*, annually infest quantities of dried beans,

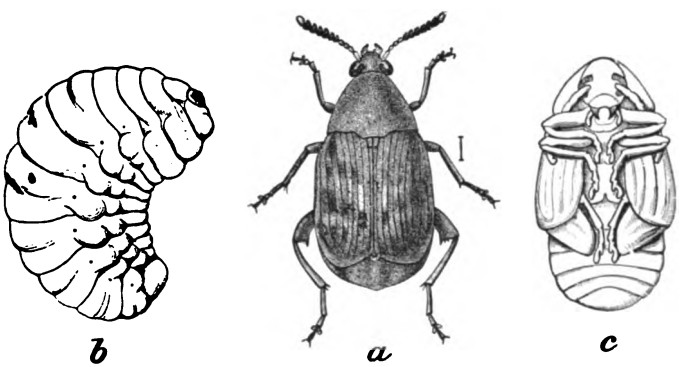

FIG. 7.—Common Bean Weevil, *Bruchus obtectus*: *a*, beetle; *b*, larva; *c*, pupa—all greatly enlarged. (Chittenden, Yearbook, 1898, U. S. Dept. of Agr.)

rendering them unfit for food or seed. Infested beans are readily detected, upon examination, as every housekeeper could testify. Many people believe that beans become infested *only* after they are stored, and such may at times be true, but a large proportion are first infested in the field or garden.

LIFE HISTORY AND HABITS.

Dried stored beans once infested with weevils may continue to become worse infested by successive generations. If not disturbed the

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weevils may produce five or six generations each year and single beans may contain a number of weevil larvæ at one time.

Ordinarily, beans first become infested in the field, the weevils depositing eggs through slits or cracks in the green pods, and the larvæ, as soon as formed, bore into the beans. Their presence is indicated only by a small black speck on the skin. In dried beans, the weevils are readily detected because they eat away all but a very thin layer of outer skin.

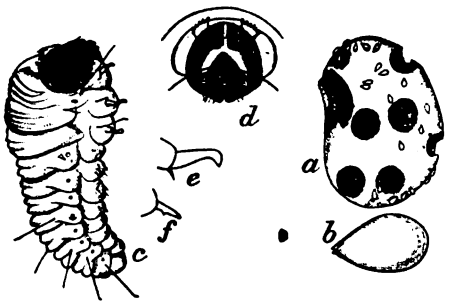

FIG. 8.—The 4-Spotted Bean Weevil, *Bruchus 4-maculata:* Showing cowpea (*a*) with holes made by weevils, and also eggs on the surface; *c*, embryonic larva. (Chittenden, Yearbook, 1898, U. S. Dept. of Agr.)

The adult bean weevil *B. obtectus,* is about one-sixth inch in length, grayish brown in color, and has the end of the abdomen extending beyond the wing covers. Other species of bean weevils differ in size and coloration, but all may be distinguished by the short wing covers. Fig. 8 represents the four spotted bean weevil, *B. 4-maculata.*

REMEDIES.

There is no way of preventing infestation of beans in the field if the parent beetles are present. To prevent their being present stored beans, peas and cowpeas should be thoroughly fumigated during fall and winter, so that no adult beetles may escape. The method of fumigation is fully described under pea weevils, p. 48. (See also corn weevils, p. 39.)

INSECTS AFFECTING BEETS.

CUTWORMS (See under Bean Insects, p. 11).
FLEA BEETLES (See under Cucumber Insects, p. 44).
WEB WORM (See under Cabbage Webworm, p. 23).
WIREWORMS (See under Corn Insects, p. 31).

BEET LEAF-MINER *(Pegomyia vicina,* Lint.).

This insect may not occur in North Carolina, but if not this particular species, some similar ones do occur. The beet leaf-miner is common in States where the sugar beet is grown and may cause considerable injury. Many garden plants are injured more or less by leaf-mining insects, hence the brief account here given of the beet leaf-miner should be of general interest.

Beets and other plants are often found with raised or blistered

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blotches, or channels in the leaves, these areas eventually turning brown and dying, rendering them unfit for greens. The cause of this damage is a small larva or maggot feeding between the two surfaces of the leaf.

The adult of the species mentioned above is a two-winged fly, resembling the common house fly, only smaller. The eggs deposited by these flies hatch into minute maggots, that bore at once into the leaves. When grown the maggots usually leave their channels to pupate.

PREVENTIVE MEASURES.

As sprays are useless to poison the larvæ, the gardener's recourse is to destroy the infested leaves. When beets, turnips, etc., are used for greens, all discarded leaves should be burned rather than left in the fields. The insects pass the winter in the pupæ stage under leaves and rubbish, and may be destroyed by clean cultural methods.

INSECTS AFFECTING CABBAGE, COLLARD AND CAULIFLOWER.

A long list of insects are known to attack these and closely related crops, and since no garden operation is complete without these valuable plants, their insect enemies should be well understood.

CUTWORMS.—(See under Bean Insects, p. 11).

FLEA-BEETLES.—Poison applications used against cabbage worms, p. 22, should also control the flea-beetles. The reader should refer also to control of flea-beetles on cucumbers, etc., p. 44.

CABBAGE APHIS (*Aphis brassicæ*, Linn.).

Green lice on cabbage, collards, and related crops, familiar to all gardeners, may appear early in the spring, but are generally most abundant and destructive in late summer and fall. Particularly is this true in fall after cool weather commences, and is due mainly to the fact that natural parasitic enemies are able to keep the lice reduced to small numbers during warm weather.

LIFE HISTORY AND FEEDING HABITS.

Cabbage aphis, like all plant lice, feed by piercing the plant tissue with their long, slender beaks and sucking the plant juices. When numerous they may cause plants to wither and die, and only small numbers may serve to stunt the growth. These lice multiply very rapidly, the young being born alive by both winged and wingless viviparous females. The winged females serve to spread the colonies, that is, a single winged individual may fly to an uninfested plant and start a new colony. No true males and females are present during

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the summer months, but are developed by the last brood. A winged male is shown in Fig. 9, a. The true females develop eggs that serve to carry the species through the winter. Colonies of cabbage lice are usually more or less covered with a white powder, which they secrete, and great numbers of molted skins are always present.

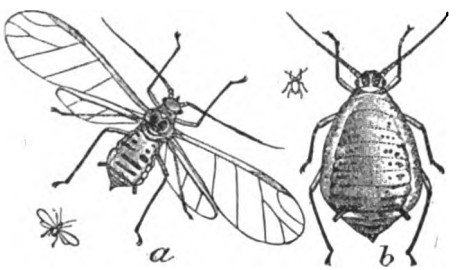

FIG. 9.—Cabbage Louse: *a*, winged male; *b*, wingless female—much enlarged.

PARASITES.

Were it not for the number and activity of parasites attacking the cabbage aphis, this would be a very serious pest. Predaceous parasites, such as lady-bird beetles and their larvæ, and aphis lions, together with internal parasites belonging to the Hymenopterous insects, usually serve to keep the aphis down to comparatively small numbers during warm, dry weather in summer. Later, the lice become more numerous, mainly because their parasites are not so active or else they stop work entirely because of the cold weather.

REMEDIES.

Soap Solution.—For all lice, as previously stated, contact sprays of sufficient strength are effective. It is surprising how easy the cabbage lice may be killed with soap solution, which acts by suffocation and caustic effect. Ordinary strong potash washing soap, or powder, will do the work. Dissolve one pound in about four gallons of water and apply to infested plants with considerable force and in liberal quantities. The lice are often so thickly massed together that those underneath will escape unless the solution is applied as a fine spray and with *force*. A spray pump is quite necessary and should be provided with a short hose and extension rod with a curved end, in order to throw the spray on the under sides of the leaves. Failing in this, the leaves must be turned over and the colonies of lice saturated with the solution. *Simply sprinkling the tops of infested plants does very little good.*

Other Contact Sprays.—Kerosene emulsion of 10 part concentration, tobacco decoction, pyrethrum powder and whale oil soap (See p. 63 for direction for preparing) are all good remedies, but not superior to common soap solution when properly applied.

TERRAPIN OR HARLEQUIN BUG (*Murgantia histrionica*, Hahn.).

This gayly colored plant bug, so common and destructive, is another sucking insect, feeding on the plant juices. Its attack is more serious than the plant lice because, in addition to sucking the sap, it

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injects into the plant tissue a poison that causes the foliage to turn brown, shrivel and die. A very few terrapin bugs may kill young plants. They attack all cruciferous crops.

DESCRIPTION AND HABITS.

Adult Bugs.—The fully grown bugs are about three-eighths inch in length, and one-fourth inch wide. The head is short, with the long beak springing from beneath and lying between the legs when not in use. The body presents a blunt, broad-shouldered appearance. The general color is black with orange or yellow markings. (See Fig. 10.)

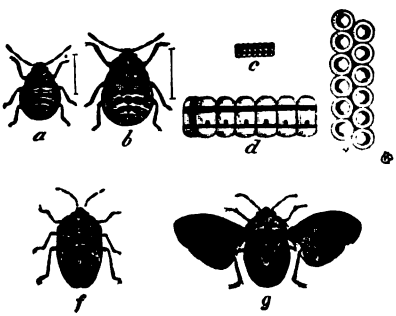

FIG. 10.—Terrapin Bug: *a* and *b*, nymphs; *c*, eggs; *d*, eggs enlarged; *f* and *g*, adult bugs.

The adults live in hibernation during winter in any protected place.

Eggs.—Are usually laid on the under sides of the leaves in double rows of twelve, as shown in Fig. 10, e. Each egg appears barrel-shaped and is marked by black bands, Fig. 10, d.

Nymphs.—The young, called nymphs, resemble the adults except that they are smaller and lack wings. In this stage they have comparatively soft bodies and succumb to strong contact sprays.

REMEDIES AND PREVENTION.

Old fields of collards and similar crops are veritable feeding grounds for terrapin bugs. By thorough cleaning up of such fields in fall much trouble may frequently be averted. Strict cleaning up and burning of all stray plants and rubbish about gardens and fence corners during winter will destroy many hibernating adults.

Trap Plants.—The adult bugs, first appearing in spring, seem to be partial to mustard, radish and rutabaga plants, and these may be planted early and used as trap plants. Only a few are necessary. The bugs that gather on such plants may be collected by hand or shaken into a pan containing a little kerosene, and when eggs are deposited and nymphs appear they may be killed by spraying with 15 per cent kerosene emulsion, or with pure kerosene, but the latter will kill the plants. When the trap plants become too badly infested, they may be pulled and burned. Persistent warfare in early spring should so reduce the number of bugs as to protect the later crops.

Kerosene Emulsion.—When used liberally of 15 per cent concentration (See p. 63) this will kill all the young and nearly mature

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nymphs that it comes in contact with and will kill some adult bugs. Before the wings are developed, the bugs are not so difficult to kill. Two or three such sprayings at intervals of five or six days should nearly exterminate the bugs, even on badly infested crops.

When spraying with emulsion, many bugs drop from the plants to the ground, and should be thoroughly saturated where they lie, and this is quite important, as very few will live to return to the plants. Kerosene emulsion must be properly prepared, so that the oil does not readily separate, otherwise the plants may be injured by the spray.

CABBAGE WORMS.

No less than five distinct species of leaf-eating worms are annually present, and are quite injurious to cabbage, collard, turnip and related plants. One species, the cabbage web worm, has never before been reported as occurring in North Carolina. In addition to the five different worms mentioned below, cabbage and related crops may at times be attacked by the larvæ of the Southern cabbage moth, zebra caterpillar, army worm, corn worm, yellow woolly bear, and possibly other minor leaf-eating pests. The following, however, are the only ones that the gardener need fear:

Imported Cabbage Worm (*Pontia rapæ*, Linn.).

As the name implies, this destructive pest was introduced into this country from Europe, first appearing in the United States about 1865. It is now prevalent throughout North America and Europe. Although an introduced pest it has far outstripped in numbers the native cabbage worm, described further on.

DESCRIPTION AND HABITS.

Parent Butterfly.—The parent of the imported cabbage worm is a white-winged, active, day-flying butterfly. The majority of the white butterflies that hover about cabbage and collard fields on bright, sunny days are the adults of this species.

The female butterflies have white wings expanding about one and three-fourths inches, the front wings having a black spot at the tip and two black dots near the center, while the hind wings have only one black dot near the front margin (Fig. 11). The males differ in having only one black dot on the forewings, but otherwise closely resembling the females. The butterflies deposit eggs on all cruciferous crops, but particularly on collard, cabbage, and cauliflower.

Eggs.—These are laid on the under sides of the leaves; they are oval in shape, white at first, but soon assume a yellow color, and hatch

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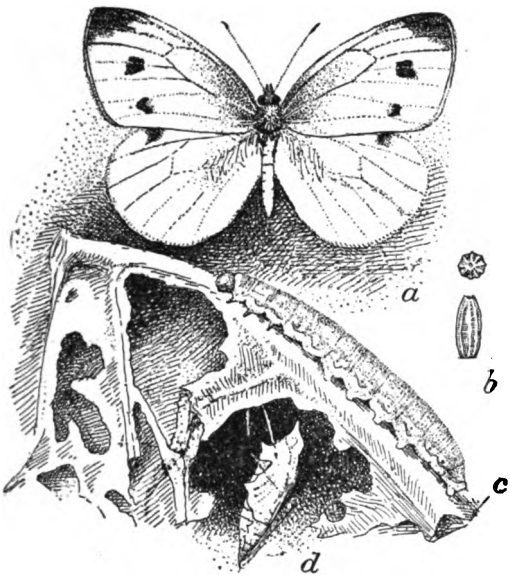

FIG. 11.—Imported Cabbage Worm: *a*, female butterfly; *b*, egg—much enlarged. *c*, larva in natural position; *d*, pupa suspended; (Chittenden, Cir. 60, Bur. of Ent., U. S. Dept. of Agr.)

in four to eight days. They may be easily located on the plants by watching the female butterfly as she deposits them one at a time.

Larvæ.—The larvæ or young worms feed on the lower surface of the leaves, or in the opening bud, and rapidly increase in size, attaining full growth in about two weeks. They then appear green in color, one and one-fourth inches long, with a pale yellow stripe along the middle of the back. The body is clothed in short hairs, giving it a velvety green appearance. They move slowly without lifting the body, which they are enabled to do by possessing eight pairs of legs. This species seems to prefer to feed on the central leaves.

Pupæ.—The grown larvæ change to naked pupæ suspended to the underside of a leaf by a silken cord about the body and the tip of the abdomen attached to a mat of silk. Fig. 11, d, represents a pupa suspended, but not in its natural condition. The pupæ are irregular in shape, light green, and inactive except for being able to wriggle the abdomen when disturbed.

LIFE HISTORY.

Pupæ, also known as chrysalides, of the last fall brood, live through the winter. In the spring they transform into butterflies, which soon commence to deposit eggs. In warm weather the entire life cycle from egg to butterfly is completed in about thirty days, or less, so that five or six broods may develop during the year in the South. There are three broods in the New England States.

This, we see, is an insect having four distinct stages of development as already described, and naturally the larval or feeding stage is the time when it may be destroyed most readily, although adults may be caught in nets, and pupæ sought for and destroyed.

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REMEDIES.

Poison Sprays.—A prejudice seems to exist against the use of poison sprays on cabbage, collard, etc., but it is largely without foundation. Garman, Entomologist of Kentucky, has made exhaustive experiments with Paris green mixture and found that it may be used safely if reasonable care be exercised in its application. Certainly the arsenical sprays are more effective against the worms than most other remedies on young and half grown plants. Garman sprayed cabbages four times with Paris green mixture, using as much as one pound of Paris green in one hundred gallons of water, and about two weeks after the last application he had entire cabbage heads, outer leaves and all, subjected to chemical analysis. Only a slight trace of poison could be detected; not enough to poison a person under any conditions. As cabbages grow from the inside outward, and the outer leaves are always removed before cooking, the writer does not hesitate to recommend the use of arsenical sprays until within three or four weeks of the time when such plants will be eaten. Cruciferous plants grown for greens alone may be poisoned also, using the same precaution. Resin-lime mixture, or Paris green-lime mixture, as recommended under formulas, page 62, will suffice to keep this and other cabbage worms in control. Four annual sprayings are usually sufficient.

Fresh hellebore acts as a poison both by contact and internally. It may be dusted on infested plants every two or three days, or used as a liquid spray.

Contact Sprays.—Cabbage worms, being soft-bodied and breathing through pores in the body, will succumb to contact sprays such as ten per cent kerosene emulsion, strong soap solution, or by dusting with common ar-slaked lime or ashes. Hand picking of worms from small areas is often advisable.

Preventive Measures and Trap Crops.—All remnants of cruciferous plants should be removed from the gardens and fed to stock or burned as soon as the crop is gathered, especially during late fall and winter, for the destruction of such plants will destroy many overwintering pupæ of the imported cabbage worm, and also those of nearly all injurious cabbage worms. Trap plants may be left in the field in fall to attract the butterflies to deposit eggs, but these should be freely poisoned and destroyed entirely before spring.

Parasites.—Several parasitic enemies assist in keeping the imported cabbage worm in control.

Native Cabbage Worm *(Pontia protodice,* Bd.).

Unlike the cabbage worm just described this is a native North American species, and is said to be more abundant in the South than

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in the North. Near Raleigh during October, 1907, no worms of this species could be found, but earlier in the season they were probably numerous. Doubtless the parasites got very active and nearly exterminated this species in this section last fall.

DESCRIPTION AND LIFE HISTORY.

The adult male butterflies resemble the imported species, already described, in size and color, but differ in having four angular spots on the front wings and small black marks near the tip, while the hind wings are not marked. The females differ very greatly in having both pairs of wings liberally checkered with angular black spots.

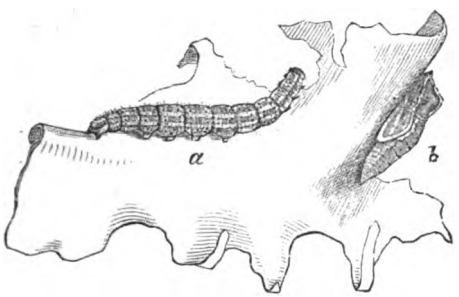

FIG. 12.—Native Cabbage Worm: *a*, larva; *b*, pupa. (Yearbook, 1888, U. S. Dept. of Agr.)

The eggs are laid singly on the undersides of the leaves.

The larvæ (worms) are greenish or purple in color and differ from the preceding form by having four longitudinal pale yellow stripes along the back. The head and body are dotted with black. The pupæ resemble those of the imported species and are similarly attached to the leaves (Fig. 12).

The life history of this species is practically the same as that of the imported cabbage worm.

REMEDIES.

The remedy is the same as for the imported species and one can not well be controlled without destroying the other.

Parasites.—Several beneficial parasites attack the native cabbage worm, often rendering other remedial measures unnecessary.

CABBAGE WEBWORM (*Hellula undalis,* Fab.).

Another imported pest of cruciferous crops is the webworm, a most injurious species, new to North Carolina, and of a comparatively recent occurrence in North America. The writer first discovered this pest quite abundant on turnips at West Raleigh in October, 1907, and it appears never to have been discovered previously in any part of this State. The webworm had of course been here all through 1907 and probably one or two years before, but without being detected.

HISTORY OF THE CABBAGE WEBWORM.

This insect was discovered in injurious numbers near Augusta, Ga.,

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in 1898, but had been observed there the previous year. In Richmond County, Ga., in 1898, the damage caused by webworms to turnips, cabbage, beets, etc., was estimated conservatively at $20,000, and by some persons as high as $50,000. This serious outbreak led to an investigation by the Bureau of Entomology, Washington, D. C., which brought out the fact that the same insect had appeared near Charleston, S. C., in 1895, considerable damage in that vicinity being reported also in 1896. Three years later, in 1899, injury from webworms was reported from Auburn, Ala., and Athens, Ga., but the damage near Augusta, Ga., was not nearly so great as it had been in the year 1898.

From the information available it is thought that the cabbage webworm was first introduced near Charleston, S. C., and spread from there to Augusta, Ga. Now that it has been found at West Raleigh there is every reason to believe that in many places in North Carolina it already has a good foothold. Therefore our farmers and gardeners should study the following description and learn to recognize the pest.

INJURY CAUSED BY WEBWORMS.

The worms seem to prefer feeding in the bud of young plants or on the undersides of the leaves, or in the crown of plants like turnips and beets. On turnips, they may burrow into the crown, making shallow channels, and also eat off the leaves at their bases. The worms cover themselves with a web, probably remaining under it most of the time, though they may leave it at night to feed. When grown the worms spin silken cocoons, which are usually imbedded in a mass of web. Young plants are prevented from growing by the worms eating the bud, and older plants may be ruined in a few days if the worms are abundant. The presence of webworms is indicated by webs between the bases of the leaves of cabbage, collard, etc., and in the crown of beets and turnips. The worms may usually be found under the webs.

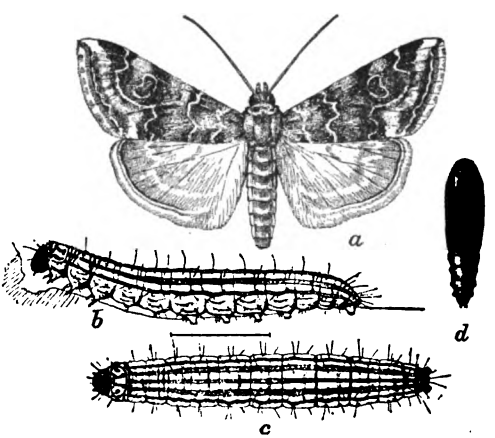

FIG. 18.—Cabbage Webworm: *a*, parent moth; *b*, and *c*, larvæ; *d*, pupa—all 3 times natural size. (Chittenden, Bul. 19, Bur. of Ent., U. S. Dept. of Agr.)

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DESCRIPTION AND HABITS.

Eggs.—Eggs are laid singly or in masses, according to Chittenden,[1] and are at first white, changing to pink; the shape is oval, size small, but discernible to the naked eye; they hatch in three to four days.

Larvæ.—Full grown webworms are quite distinctive in appearance. They measure a little over one-half inch; color yellowish gray, marked above by five noticeable brownish stripes (Fig. 13, b, c); body dotted by a few yellowish or brownish hairs. The larvæ have eight pair of legs, three pair true legs in front and five pair pro-legs behind.

Pupæ.—These are not readily found because of being enclosed in tough silken cocoons spun between the leaves or in the crown of turnips and beets. The pupæ are shiny yellowish brown in color, and are about three-tenths of an inch in length (Fig. 13, d). As they pass the winter in this stage an excellent opportunity is presented to reduce their numbers by clean cultural methods.

Parent Moths.—In general shape and markings the moth is well shown in Fig. 13, a, much enlarged. The true size is about three-fourths inch when wings are expanded, but when resting with wings folded over the body they appear much smaller. The fore-wings are gray, marked with both darker and lighter stripes and spots. Hind wings are lighter in color. The moths fly and deposit eggs at night, and hide during the day.

Generations.—No definite information concerning the number of annual broods for North Carolina is available. We do not know how early the webworms become abundant, nor much about their life history. On this point, and many others, the writer hopes to get definite information this coming summer by field and laboratory observations. The life cycle as determined by Chittenden is about 27 days, but will, no doubt, be found to vary.

REMEDIES.

Arsenical Poisons.—Poisons if effective must be applied early, for when the protecting webs have been spun, poison sprays will not be of value. If the worms are detected when they first appear, some of them, and especially succeeding broods of larvæ may be poisoned. In other words, a poison spray applied thoroughly so as to penetrate well in between the bases of the leaves where the webworms commence to feed will kill many of the young. For this spray, it would be best to use Paris green, at a strength of 1 pound to 125 gallons of water with lime (See p. 60) or arsenate of lead at the usual strength. Dry dust poison applications may answer the same purpose if applied

[1] Bureau of Ent. Bul., 23, p. 59.

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with a good powder dust gun that will throw the mixture forcibly into all crevices. As soon as the first worms appear apply poison liberally.

Trap Crops.—Webworms seem to prefer cabbage and turnips, hence it would seem that these might be planted early and thoroughly poisoned to destroy the early broods. This would be a great protection to later crops of similar and related plants.

Clean Culture.—Webworms may undoubtedly be prevented from increasing in numbers by carefully burning or feeding, if suitable, all remnants of infested plants during fall and winter. When early crops are infested burn or feed the plants when the crop is gathered. Such practice is advisable against other cabbage worms that pupate on the plants and winter in that condition.

Cabbage Looper (*Autographa brassicæ,* Riley).

This is probably the most injurious cabbage worm in North Carolina. Cabbages, collards, and rutabaga turnips are often almost stripped of their outer leaves, and the worms may bore into the cabbage heads. They move by a looping motion, rendering them easily recognized from the other common cabbage worms.

Fig. 14.—Cabbage Looper (*A. brassicæ*): *a*, male moth; *b*, egg (two views); *c*, larva in natural position; *d*, pupa under thin cocoon—*a*, *c*, *d*, slightly enlarged; *b*, more enlarged. (Chittenden, Bul. 88, Bur. of Ent., U. S. Dept. of Agr.)

Description and Habits.

Eggs.—Are small, pale green, round and flattened on one side with convex side up, and are deposited singly or in small clusters by the female moths about sundown or at night.

Larvæ.—When full grown they are one and one-half inches, or more, in length, pale green, marked with four fairly distinct stripes along the back. Less distinct longitudinal lines also occur. The body is smallest at the anterior end and bears three pairs of true legs on the first three segments, and three pair of pro-legs near the caudal end, one pair being on the last body segment (Fig 14, c.).

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Because of not having pro-legs in the middle of the body these caterpillars move with a semi-looping motion, much like the familiar "inch or measuring worm."

Pupæ and Cocoons. The larvæ change to pupæ under thin silken webs on the under sides of the leaves, as shown in Fig. 14, d. The pupæ are about one-half inch long, shiny brownish in color, and may be seen through the thin webs.

Parent Moths.—From the pupæ, moths as shown at Fig. 14, a emerge to lay eggs for the succeeding brood. The moths have a wing-expanse of nearly one and one-half inches; fore-wings grayish brown and marked by a silvery dot and loop near the center; hind wings are lighter. They fly at night or about sundown, and hence escape observation.

Generations and Winter Stage.—Several generations occur each year and are checked only by cold weather. The last brood passes the winter as pupæ, which shows that fall and winter destruction of old infested plants should be practiced.

REMEDIES.

All remedial measures, trap plants, clean culture, etc., suggested above to be used against the imported cabbage worm, should be employed against this species.

Diamond Back Moth or Cabbage Plutella (*Plutella maculipennis*, Curtis).

Although a small worm, this species may cause considerable damage by feeding on the undersides of the leaves and producing small, round holes. They do not often cut through to the upper surface. The larvæ much resemble the young imported cabbage worms, but may be distinguished from them by being extremely active if disturbed.

The parent moths are only about one-fourth inch in length and are seldom seen. They lay minute whitish eggs, which hatch within a few days. The larvæ are a little over one-fourth inch in length, of a pale green color, and when grown encase themselves in white cocoons, which are attached to the leaves. There may be several broods during each season.

REMEDIES.

Poison Spray, as previously recommended, is effective, and Garman states that tar-water has been found very effective in European countries. The winter is passed in the pupa stage, hence clean culture is most advisable.

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Cabbage Root Maggot (*Pegomyia brassicæ*, Bouché).

Small, white footless maggots sometimes infest the roots and base of cabbages and radishes and other related crops. There are probably two or three species of cabbage maggots in North Carolina, but a description of the one mentioned above will serve to give the gardener or trucker an idea of these pests and their habits.

DESCRIPTION AND LIFE HISTORY.[1]

Maggots are the young or larvæ of two-winged flies (Fig. 15). This species somewhat resembles the common house fly, only they are much smaller. They pass the winter as adults or pupæ, the latter remaining close to the roots of the plants on which the maggots subsisted. The flies appear in spring at about the time young cabbage plants are set out, and lay eggs on their stems or on the soil close by. The maggots feed on the outer roots, or stems when the latter is not too tough and hard.

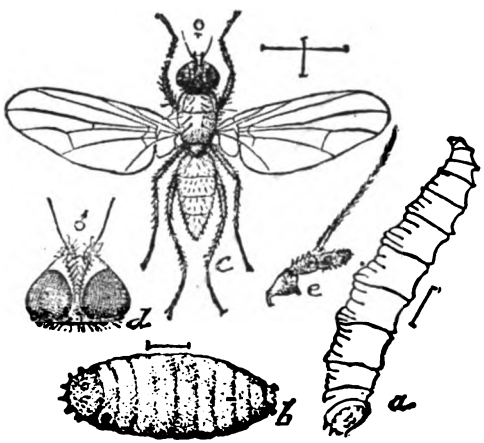

Fig. 15.—Cabbage Maggot: *a*, larva; *b*, pupa; *c*, adult. (Riley).

The presence of maggots is indicated by wilting and drooping leaves, and a general weakened appearance of the plants. It is said that plants infested when young will surely die, unless some good remedial measure is applied.

REMEDIES AND PREVENTION.

Tobacco dust applied liberally about the plants when first set out is of some benefit as a repellent.

Carbolic acid emulsion as recommended against the onion maggot, p. 47, may be used as a repellent.

Quick Acting Fertilizer.—Concerning the use of fertilizers Dr. Smith says: "A combination recommended consists of:

Nitrate of Soda	700 lbs.
Acid Phosphate	1,000 lbs.
Muriate of Potash	300 lbs.

[1] N. J. Sta. Bul., 200.

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"The practice of plowing away from onion rows when infestation was noted and applying the above combination, or even nitrate of soda alone, has been followed with good results in Cumberland County, but has failed on heavier soils where the fertilizer did not get so quickly through the soil, and into direct contact with the plants and maggots. Both the nitrate of soda and the muriate have insecticidal qualities, but the acid phosphate has none. Manure and organic fertilizers should be avoided, if possible, as the group of insects to which these root maggots belong are naturally feeders in decaying matter, and hence such conditions tend to invite them."

Prevention.—Pull up and burn or otherwise completely destroy all stumps of plants, of whatever crop may have been attacked by maggots. Practice rotation of crops, for the parent insects do not fly very far. The cabbage maggot will breed in wild cruciferous plants, including some common weeds, such as mustard, hence all such should be destroyed. A good precaution when setting cabbage, or similar plants, is to press the soil firmly about the stem, as it will help to retard the maggots, when hatched, from getting down to the soft roots.

Planting an excess of seed when drilled in rows may insure getting a stand even where a large number of plants are attacked by maggots. The plants that become infested should be pulled out and destroyed. The reader should refer also to p. 47 concerning treatment for the onion maggot.

Cabbage Snake *(Mermis albicans,* Diesing).

During recent years much excitement has been caused by the discovery of slender, white worms in cabbage heads, known as "cabbage snakes," and which have been reported as being deadly poison. How such accounts have originated it is hard to realize. The "cabbage snake," so called, commonly found, is shown in Fig. 16. It is an "eel-worm" or "hair worm," and occurs as an internal parasite in the bodies of grasshoppers, happening at times to escape from its host onto cabbage heads, which alone accounts for its presence there. These slender, thread-like creatures are active and repulsive looking, but never poisonous.

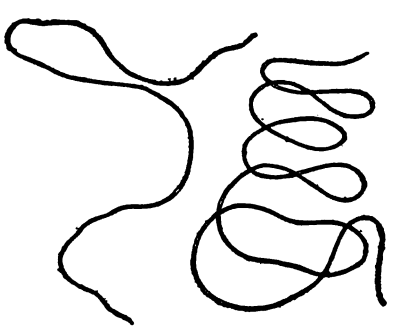

Fig. 16.—"Cabbage Snake" or Hair-Worm: Natural size. (Chittenden, Cir 62, Bur. of Ent. U. S. Dept. of Agr.)

Small, segmented, reddish earthworms occasionally get into cab-

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bage heads, by being accidentally lodged there with small clods of earth during cultivation. There is no danger from eating cabbage that have contained these worms, or the common "cabbage snake."

INSECTS AFFECTING THE CELERY PLANT.

CUTWORMS.—(See under Bean Insects, p. 11).

CELERY CATERPILLAR *(Papilio polyxenes,* Fab.).

This is a very large, conspicuous green and black caterpillar, familiar to many children because of its peculiar appearance. It seldom appears in great numbers, but if present is a voraceous feeder on various plants, including celery, carrot, parsley, caraway, parsnips, and related wild plants.

DESCRIPTION AND HABITS.

Caterpillars.—Are about two inches in length, green in color, with rings of black, which in turn bear yellow spots. The head bears a pair of horn-like processes that may be thrust out and which emit a disagreeable odor. The body is thrown into a peculiar defensive like attitude when disturbed.

Pupæ.—When full grown the caterpillars generally desert the plants on which they fed and crawl to some convenient place to pupate. The pupæ are naked, of an ash-gray color, and are suspended by a silken band and mat of silk at the caudal end. In this quiescent stage they pass the winter.

Parent Butterfly.—The adult form, commonly known as the "black swallow-tail," is very conspicuous. The wings are blackish-brown, and marked with yellow and orange bands and spots.

REMEDIES.

As there may be several broods each season the gardener should be on the watch for their first appearance. The caterpillars are so conspicuous that hand picking is probably the best remedy, and if the larvæ of the first brood are destroyed later injury may be prevented. Paris green mixture (See p. 60) will be found effective and might be used with profit on the young plants in extensive celery fields.

OTHER CATERPILLARS ATTACKING CELERY.

Celery Looper, *Plusia simplex,* closely related to the cabbage looper, and the celery leaf-tyer, *Phlyctænia ferrugalis,* is a small caterpillar that usually feeds on the terminal leaves and may at times become troublesome. Spraying young plants with arsenical poisons should prove effective, and is perfectly safe if the poison is used in reasonable amounts.

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Celery Lice.

Celery is occasionally infested with plant lice of various species, whose attack results in lessened vitality and dwarfed plants. Should this occur, a thorough spraying with soap solution, as suggested for cabbage aphis, p. 18, will be found effective. Soap solution may be applied frequently without injury. Tobacco decoction is always quite effective against plant lice.

Red Spider *(Tetranychus spp.)*.

These little creatures, frequently called mites, are not true insects. They are, however, a very common garden pest, and attack at times almost any vegetables, particularly cucumbers, cantaloupes, egg plants and many common crops. They are most abundant during hot, dry weather, and then if present they cause the foliage to turn yellow and eventually die. The individuals are very small and rather active; and may feed on both upper and lower surfaces of a leaf, spinning over it a thin web for protection.

REMEDIES.

Abundant moisture will keep red spiders in check. When a good spray or force pump is available, they may be controlled by simply making frequent applications of ordinary clear water, applied with all the force the plants will endure, washing both sides of the leaves. This method is used in greenhouses, to keep the mites off of violets, roses and other plants.

Powdered sulphur (flowers or flour of sulphur) applied as a fine spray, using one ounce of sulphur in a gallon of water or the dry powder dusted on the plants when wet with dew will be found very effective. Potassium sulphid *(liver of sulphur)* obtainable from drug stores, may be used as a spray of one ounce in three gallons of water. It is said that a little whale oil soap, tobacco-stems water, or milk of lime added to the sulphur mixture increases its efficiency.

INSECTS AFFECTING SWEET CORN.

Numerous insects attack corn, some injuring the seed when first planted, some damaging the young plants, others attacking the stalk and ears when partly grown, while still others damage the stored grain. Only the most common injurious forms will be mentioned here, as the entire space of a bulletin is needed to adequately discuss all the corn insects.

Wireworms *(Several Species)*.

These insects hardly require description, as they have become so well known by their attacks on various crops. Wireworms injure

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corn by the larvæ boring into the kernels when first planted and later by entering into the stalk of young plants, causing them to die in the same way as when injured by budworms or rootworms.

DESCRIPTION AND HABITS.

Larvæ.—Wireworms in general may be described as having long, slender, cylindrical, firm bodies, showing segmentation, usually flattened toward each end. They vary in size according to the species to which they belong, some being less than one, others nearly two inches long. The majority are reddish or yellowish in color, presenting a very hard, slick appearance. Some wireworms feed on decaying wood and organic matter, while others subsist on seeds and roots of plants.

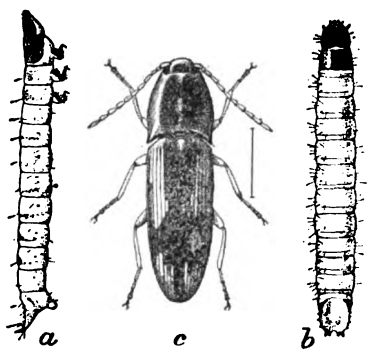

FIG. 17.—Wireworms: Larvæ and adult—all three times natural size. (Chittenden, Bul. 33, Bur. of Ent., U. S. Dept. of Agr.)

Parent Beetles.—These are commonly known as Jack snappers, click beetles, thumping beetles, and by other terms, gained for them by the power of springing several inches in the air, in an effort to turn over when laid on their back.

The common click beetles are from one-third to one inch in length, generally of a brown color and are variously marked. A common species is pictured in Fig. 17.

LIFE HISTORY.

The parent beetles may hibernate in protected places, but many larvæ pass the winter in the soil. It is thought that most species of wireworms require three years to mature, hence two winters of their life must be passed in the ground. This fact shows how difficult it may be to free a field from these pests. The beetles of the injurious species, generally deposit their eggs in grassy places, though the species that feed in decaying wood may lay eggs in old stumps, etc.

REMEDIAL MEASURES.

No single method of control is effective. Various methods of reducing the numbers of wireworms in fields already badly infested have been advocated. The most promising are, early fall plowing to disturb the larvæ, followed by cross plowing and harrowing once or twice during winter, and the use of poison baits in spring. A good bait is made by treating slices of potatoes or turnips with strichnine, and other baits are mentioned under remedies for cutworms, p. 14.

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Crops peculiarly liable to attack, like corn, potatoes, beets, turnips, etc., should never be planted on land known to be infested, unless absolutely necessary.

Rotation of crops may do some good. It is difficult to name an immune crop. Legumes, as a rule, are not much injured by wireworms, but that may be due to their abundant root system. A rotation that allows the land to be broken every fall or winter will naturally tend to reduce the numbers of these insects.

Planting an excess of seed when corn must be planted on infested land may insure getting a stand.

CORN ROOTWORM (Budworm), *(Diabrotica 12-punctata,* Oliv.).

This corn pest belongs in the same category as the wireworms in being difficult to control. Rootworms damage young corn plants by

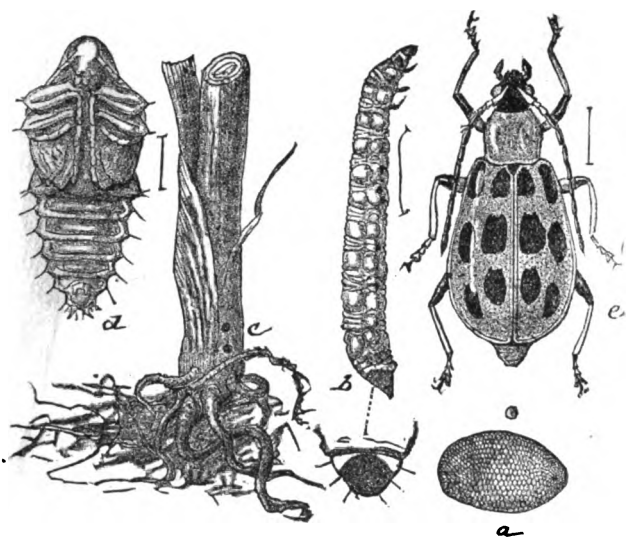

FIG. 18.—Corn "Root-worm" or "Bud-worm": *a*, egg; *b*, larvæ; *c*, injury o corn plant; *d*, pupa; *e*, adult beetle—all except *c* much enlarged. (Redrawn from Riley, Div. of Ent., U. S. Dept. of Agr.)

eating into the stalk at or near the ground, and very young plants may be killed outright, while older ones will be caused to make a dwarfed growth because of having the central bud destroyed. Fig. 18 illustrates the insect in its different stages, and an injured plant.

DESCRIPTION.

Larvæ.—These are slender, yellowish white grubs with a brown head and body about one-half inch long. They attain full growth in three to four weeks.

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Pupæ.—The larvæ change to naked whitish pupæ in little cells in the soil, and after about two weeks transform again to beetles.

Parent Beetles.—Are about three-tenths of an inch long, yellowish green in color, with twelve black spots on the wings as illustrated in Fig. 18, much enlarged. These beetles are omniverous feeders on a great variety of plants, notably cucumbers, cantaloupes, etc.

LIFE HISTORY.

After passing the winter in hibernation the beetles become active early in the spring. The earliest vegetables of the garden serve as their food, working, as they do, side by side with cucumber and flea beetles. The eggs, deposited in the soil close by the base of corn plants, hatch within a short time and the newborn larvæ burrow into the stem as indicated above.

There are at least two generations, the first maturing within about six to seven weeks after the eggs are deposited. The parent beetles are present all summer, often feeding on the blossoms of fruit trees.

REMEDIES.

Commencing in early spring and following this insect through its two generations, we discover no good chance of destroying the larvæ, but there is some opportunity of killing the pupæ in the soil and of poisoning the adult beetles. The latter method, however, offers only a slight chance, for the beetles do not all feed in the gardens. Still the liberal use of poisons on cucumbers and cantaloupes, as recommended on page 43, will undoubtedly destroy some of them. Some of the pupæ may be killed by thorough weekly cultivation of the corn crop, especially during and about the sixth to tenth week after it comes up.

Good fertilization to strengthen and feed the corn plants will aid materially against slight attacks, and planting an excess of seed will often insure a stand even though the rootworms may be abundant.

Late Planting and Lowlands.—Delaying the planting of corn until two or three weeks after the usual time will allow many beetles time to deposit eggs elsewhere, thus gaining some protection. The ideal time to plant corn must be determined by experience. Corn rootworms are *liable* to be most abundant in lowlands—but they are not very choice in the selection of a feeding ground—hence some advocate the avoidance of such lands for corn.

As Sherman,[1] in writing of corn insects, has said, "All these measures will help *'some,'* but no one alone will insure immunity from attack of rootworms."

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[1] Bul. N. C. Dept. Agr., Vol. 26, No. 5.

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Larger Corn Stalk Borer (*Diatræa saccharalis*, Fab.).

Fig. 19.—Corn stalk, showing holes made by corn stalk borers. (Photo. by the author.)

Corn is often injured by a caterpillar boring in the stalk, usually most noticeable and injurious when the corn is about half grown, but young plants may be destroyed. These borers weaken the stalks, retarding the development of the ears and sometimes render large stalks worthless except for fodder. These insects are said to be most abundant during the latter part of May or early in June.

DESCRIPTION AND HABITS.

Larvæ or Borers.—These burrowing caterpillars are about one inch long, with whitish, robust bodies, speckled with brown and black spots (Fig. 20). They confine their attack mainly to the three lower joints, and may occur without apparently affecting the growth. The larvæ, however, are very active, often leaving their burrows and making new entrance holes, thus severely weakening the stalks (Fig. 19).

Pupæ.—The pupæ, usually found in the stalk above ground, are of a shiny, brownish color and are about one-half inch long.

Parent Moths.—The adult moths have a wing expanse of about one and one-half inches; the fore wings are dull yellowish brown, or nearly

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colorless; hind wings white or cream colored. The moths of the first brood appear in Georgia (where the writer studied this insect) from the middle of June to the middle of July. They probably appear about the same time in North Carolina.

LIFE HISTORY.

The reader will understand that there are two broods each season. The first brood are the progeny of the insects that pass the winter in the pupal stage, in corn stubble (presumably), while the second brood are the progeny of the moths that appear during June and July.

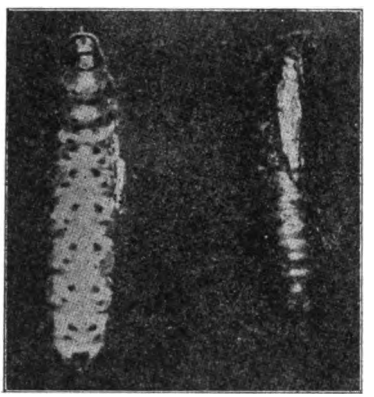

FIG. 20.—Larva and pupa of corn stalk borer. On left larva; on right, pupa—twice natural size. (Photo. by the author).

Corn is damaged most severely by the first brood, for at that time the plants are small or only partly grown. Late planted corn may be injured badly by the second brood. It seems highly probable that the corn stalk-borer has some wild host plants, some common weeds, in which many larvæ of the second brood mature. Howard[1] has reported its occurrence in Gama grass, and there must be other wild host plants. The insects pass the winter as pupæ, probably, to some extent at least, in corn stubble.

REMEDIAL MEASURES.

No truly effective remedy can be offered. It has been suggested that corn planted as late as May 15 to June 1 might escape injury, still it might also be attacked by larvæ of the second brood. When the stalk borers are observed the gardener should arrange to plow out, rake and burn the stubble as soon as the corn is harvested. Cutting the plants off at the surface of the ground will probably serve to trap nearly all the larvæ or pupæ that may be present, but such infested stalks should be fed to stock or hogs or used for ensilage. When corn is badly infested by stalk borers it would be best to use it for fodder or the silo, taking the precaution to cut the corn before many of the borers change to pupæ. The gardener can ascertain this point by frequently examining the corn plants for the presence of the brown pupa, which will certainly be found when the worms are full grown.

[1] Insect Life, Vol. IV.

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Rotation of crops is of course beneficial, but it must be remembered that the moths are capable of flying some distance in spring in search of young corn in which to deposit eggs.

Deep fall or winter plowing of corn land may serve to bury some of the pupæ so that the moths can not escape.

Corn Ear Worm (*Heliothis obsoleta,* Fab.).

This insect does not by any means confine its attack to corn, though this is perhaps its favorite food plant. It may bore into cotton bolls, and is then known as the cotton-boll-worm. When it attacks beans, peas, tomatoes, okra, tobacco and other crops, it is generally known by the name of the plant on which it occurs. The wide variation in the color of the larvæ largely accounts for its having so many names.

DESCRIPTION, HABITS AND LIFE HISTORY.

The parent is a night-flying moth, the wings of which expand about one and one-half inches and range in color from dull yellow to olive green with black markings (Fig. 21). The moths that appear in early spring, having developed from pupæ that passed the winter in earthen cells, seem to prefer to deposit eggs on young corn, and later on the silk, particularly when that is present. The larvæ, small at first, grow rapidly, attaining a length of about one and one-quarter inches, and range in color from greenish to dark brown. The markings are shown in Fig. 22.

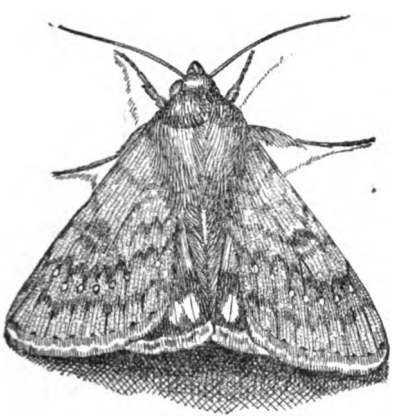

Fig. 21.—The Corn Ear-worm, showing adult moth in natural position with wings not spread —about twice natural size. (Quaintance, Bur. Ent., U. S. Dept. of Agr.)

Sweet corn is injured more severely than common field corn, but as the former is so much more preferable for table use the gardener should prepare to fight this insect.

There may be four or five broods each season, each successive brood gaining in numbers. When corn becomes hard, the moths deposit eggs on cotton, seeming to know instinctively that it will make better food for the larvæ.

REMEDIES.

The only direct remedy consists in pinching the tips of infested ears of corn to crush the larvæ within. A few rows of sweet corn may be treated in this manner. The pinching must, however, be done

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several times and at intervals of only two to three days, as the small larvæ may escape.

Trap Plants.—Remembering that the moths prefer corn silk on which to deposit eggs, we have an opportunity of using a few hills of

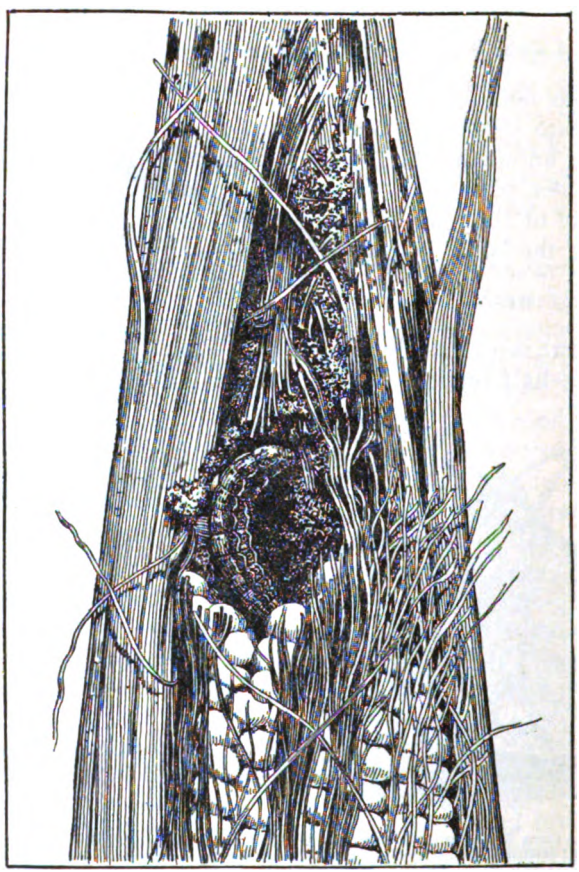

FIG. 22.—The Corn Ear-worm, showing the destructive larva at work in ear of corn. (Quaintance, Bur. Ent., U. S. Dept. of Agr.)

very early planted corn as trap plants. Early maturing varieties should be used. The larvæ are cannibalistic, devouring each other when more than one are present in a single ear, hence the trap plant is peculiarly valuable. Trap plants must be watched and destroyed, or at least the worms destroyed before any become full grown and descend to the ground to pupate. Garden crops other than corn may be protected by having a few hills of corn in silk when the other crops would ordinarily be injured.

Winter Plowing.—As already stated, these worms usually appear

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in cotton fields after the corn becomes hard, and hence it will be seen that the last generation is most liable to pass the winter as pupæ in such lands, rather than in garden or corn fields. Winter plowing of cotton fields, and gardens, where late corn has been grown, will kill many pupæ.

Corn Weevils *(Larvæ of Beetles and Moths).*

Stored corn, shelled or otherwise, is often infested with white grub-like larvæ, which may be the young of the rice-weevil *(Calandra oryzæ,* Linn.), or the granary weevil *(Calandra granaria,* Linn.), or the larvæ of the Angoumois grain moth *(Sitotroga cerealla,* Ol.). The latter is common, though the two former are better known. The two weevils are shown in Fig. 23, and the grain moth in Fig. 24. Corn may become infested with weevils in the field, but the grain moth is most liable to attack the stored corn.

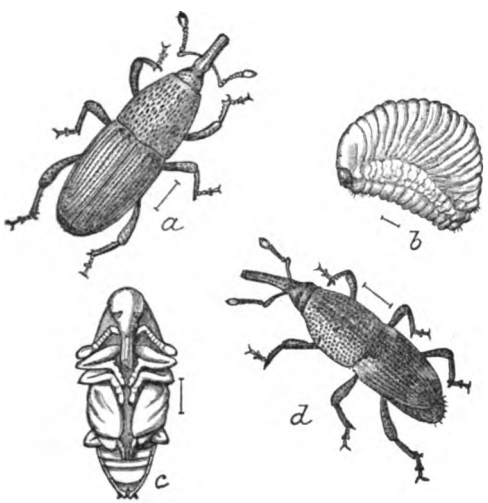

Fig. 23.—Corn Weevils: *Calandra granaria; a*, beetle; *b*, larva; *c*, pupa. *C. oryzæ*, *d*, beetle. All enlarged, (Chittenden, Farmers' Bul. 45, U. S. Dept. of Agr.)

As there is no known practical method of protecting the corn in the field we will not take space to describe these insects, but pass at once to the matter of remedies.

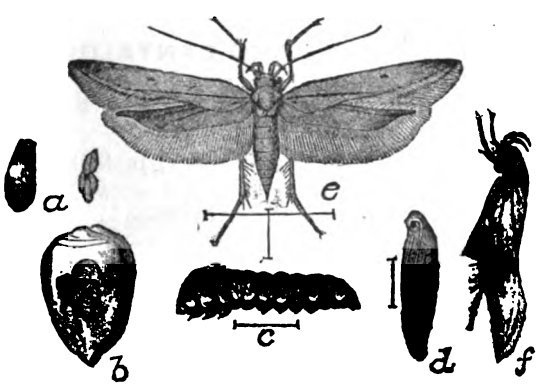

Fig. 24.—Angoumois Grain Moth: *a*, eggs; *b*, larva at work; *c*, larva; *d*, pupa; *e*, *f*, moths—all enlarged. (Chittenden Farmers' Bul. 45, U. S. Dept of Agr.)

REMEDY.

Fumigation.—Carbon bisulphid, a clear, foul smelling liquid that costs about 25 cents a pound is a certain remedy when properly used. Infested corn may be fumigated in *air tight bins* by using at least one and one-half or two pounds of carbon bisul-

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phid for about one hundred bushels of grain. The grain moth is killed more easily than the true weevils, and for the latter it may be necessary to considerably increase the recommended amount. This remedy is often condemned and declared worthless because attempts made to fumigate the corn in loose, leaky bins have failed. It evaporates rapidly and the fumes are heavier than the air, so that they will settle and escape if any cracks are left in the bottom and sides of the bin or receptacle used for the fumigating chamber. The top must be closed or covered with something, such as wet blankets and boards, to keep out any currents of air. To fumigate, expose the liquid in shallow dishes near the top of the space, or pour it directly onto the corn, afterawrd leaving the place tightly closed for twenty-four to thirty-six hours. The fumes do not act immediately, like some other poison gases, and for this reason it is necessary to prevent even gradual leakage. When corn can not be treated in an *air tight* chamber, the amount of carbon bisulphid should be increased, but even then, under these conditions, the results may not be satisfactory.

Adult weevils and larvæ may be killed by fumigation except in certain cases when they are uncommonly well protected in the kernels, but as eggs which are not killed by fumigation may be present, it is generally necessary to repeat the treatment once or twice before corn is entirely freed from weevils.

Ordinary fumigation does not injure corn for eating or planting.

Caution.—The fumes of carbon bisulphid are highly combustible and explosive, hence lighted cigars, lanterns, etc., should not be brought near where the fumigation is going on. Breathing the fumes should be prevented, as they may cause a slight or severe headache. Some people are quite easily affected.

INSECTS AFFECTING CUCUMBERS AND CANTALOUPES.

Cutworms *(several species)*.—(See under Insects Affecting Beans, p. 11).

Red Spider.—(See under Insects Affecting Celery, p. 31).

Melon Plant Louse *(Aphis gossipii,* Glov.).

Young cucumber, cantaloupe and similar plants may be attacked by small green sap-sucking lice that often cluster in great numbers on the under sides of the leaves. This same louse occurs on young cotton and is then known as a cotton louse. It is capable of causing severe stunting of growth and even death of badly infested plants. It occurs all through the summer months, sometimes injuring cantaloupes when the vines are several feet in length.

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DESCRIPTION AND LIFE HISTORY.

Plant lice, of nearly all species, breed by giving birth to living young, the adults being both winged and wingless, as shown in Fig. 25. Many generations are developed each season and during the summer the colonies of lice contain no true males or females. This development is known as parthenogenesis, that is, the young are born by females without the intervention of the male. The melon louse is no exception to this rule. True males and females are developed by the last fall brood and the oviparous females deposit eggs to carry the insects through the winter. These eggs hatch in spring into minute lice that develop into viviparous females, whose young are born alive, as already explained.

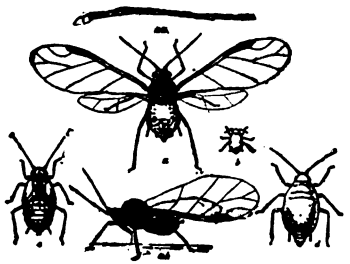

FIG. 25.—The Melon Aphis, *Aphis gossypii*: much enlarged. (Chittenden, Bur. of Ent., U. S. Dept. of Agr.)

The melon louse is yellowish green in color and about one-twentieth of an inch in length. The winged individuals of the colonies serve to spread the species, and their presence accounts for the isolated colonies that appear during the summer months. Individuals mature in six to eight days, and each gives birth to about fifty young. Considering this rapid increase it would seem that all infested plants would be destroyed, and such would be the case were it not for the valuable work of parasites, both internal and predaceous, that destroy great quantities of them. With these facts in mind, let us enter upon a consideration of the methods of control.

REMEDIES.

Spraying.—Contact poison sprays as used against cabbage lice (See p. 18) may be employed to kill isolated colonies that appear in spring.

Fumigation.—Within recent years a method of fumigating cantaloupe plants has been quite well perfected. Sanborn[1] has made valuable experiments with specially prepared tobacco or nicotine fumigating papers, manufactured and sold under the names nico-fume tobacco paper, aphis punk and to-bac-ine (See p. 64), and has perfected a system of fumigating by the use of cloth covered frames. The following description of a fumigating outfit is based on Sanborn's work:

Cloth Covered Frames.—For fumigating vines from two to four feet long construct a light wooden frame square or rectangular, of the desired dimensions, and nail an eight-inch leg to each corner. This may be covered with heavy muslin saturated with linseed oil to render

[1]Texas Expt. Sta. Bul. 89.

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it air-tight. Cut the muslin in pieces large enough to cover the frame, and also extend one foot over each side, and tack to the top, but not to the legs of the wooden frame. The loose edges of the muslin may be covered with earth to prevent any escape of gas. A frame of this construction makes a perfect fumigating arrangement, as it can be placed over any portion of a long vine if desired without damage and without disturbing the vine.

Method of Fumigating.—Use the tobacco papers, as recommended (p. 64), fumigating the infested plants from 20 to 30 minutes. This will kill all the aphis under the frames without injuring the plants. This method is said to be comparatively cheap and it is undoubtedly effective, much more so in fact than the best spraying that could be done. By having several frames in operation one or two men may fumigate large areas in the course of a day.

Beneficial Parasites.—As already stated parasites render valuable aid in controlling the melon lice. In Texas, Sanborn has shown that it pays to induce the increase of parasites by planting Rape, which usually bear the cabbage lice in abundance. This plant furnishes food in fall for a number of predaceous parasites, such as lady-bird beetles and their larvæ, that feed on the cabbage lice, and the beetles hibernate during winter among the weeds and rubbish and thus are usually present in the spring and ready to attack the first broods of melon lice. Rape, as a trap plant, should be planted in summer and fall in the gardens or on the edge of the fields where cantaloupes and cucumbers are to be planted the following year.

Striped Cucumber Beetle *(Diabrotica vittata,* Fab.).

Here we have one of the commonest and most destructive of all insects that feed on the foliage of cucumbers and related plants. It is also a difficult one to control.

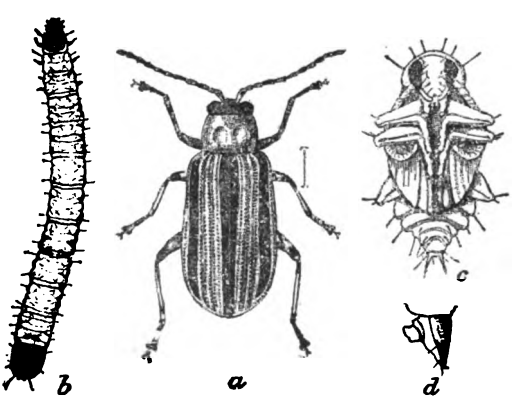

Fig 26.—Striped Cucumber Beetle: *a*, beetle; *b*, larva; *c*, pupa—all much enlarged. (Chittenden, Cir. 31, Div. of Ent., U. S. Dept. of Agr.)

Description and Life History.

Beetles.—These small, yellow winged beetles, only two-fifths of an inch long, marked with longitudinal black stripes on the wing covers (Fig. 26), usually appear early in the spring. They are voracious feeders and cause much damage to young plants. They hibernate during winter.

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Eggs and Larvæ.—Eggs are deposited at the base of young cucumber plants and hatch into small, slender, whitish larvæ that feed on the tender rootlets. The larvæ may attain a size of about one-third inch. They cause plants to wither and sometimes die. Such injury is generally overlooked by gardeners or else is laid to cutworms. The larva matures in about one month, and after passing through the pupa stage, lasting about two weeks, the change to the adult takes place.

REMEDIAL MEASURES.

All plants subject to attack should be protected from the ravages of the beetles from the moment they appear above ground until several leaves are formed, after which the plants are better able to withstand the injury. This protection is best afforded by suitable covers, but certain repellent sprays and powders may be used with profit.

Cover Protection.—The cheapest and most effective protection is afforded by box frames, about one foot square, covered with fine wire or mosquito netting, or, in the manner sometimes suggested, by cutting a barrel hoop in two to form two semi-circles, and pressing these down, crossing each other over the plants and covering all with netting. The lower edge of the cover may be held down with earth. The writer believes that the perfect protection given by these covers, allowing the plants to grow for three or four weeks without injury, more than repays the cost of material and the trouble of fixing them in place.

Spraying and Dusting.—A combination repellent and poison in the form of Bordeaux-Paris green mixture (See p. 61) is the next best thing to a cover protection. The poison Bordeaux serves as a protection against the cucumber beetle, and all leaf eating insects that may be present, and furthermore serves as a fungicide to keep the foliage healthy. When liquid spray is used this is the most economical.

A dry mixture of lime and Paris green (See p. 60) will poison many beetles and also act as a repellent, and simply dusting plants with tobacco dust, kerosene and lime mixture, or hellebore offers considerable protection, but the liquid poison spray is the most efficient. Dry applications should be applied when plants are wet with dew and repeated after every shower.

Trap Plants.—A few *very early* planted cucumber plants liberally treated with poison spray may serve to lessen the number of striped beetles and also Flea beetles, 12-spotted Diabrotica (adult of corn rootworm) and all leaf eating insects present at that time.

Planting an excess of seed is advisable if the protective measures suggested can not be used. The plants should not be thinned out too

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early, as some may die from the attack of the larvæ on the roots or from other causes.

Clean Culture.—Gardens should be cleaned up and all weeds and rubbish removed and burned during late fall or winter. This does away with the chance of leaving convenient hiding places in which this and many other garden insects may hibernate during winter. Fence rows should be cleaned out, and sod land adjoining gardens may be burned over to help destroy hibernating insects.

Cucumber Flea Beetle *(Epitrix cucumeris,* Harr.).

These small, black, jumping beetles (Fig. 27), about one-twelfth inch in length, often cause quite severe injury by eating the foliage of cucumbers, cantaloupes, melons, etc. The larvæ of this species is a leaf-miner, causing some damage, while the adults feed on the surface.

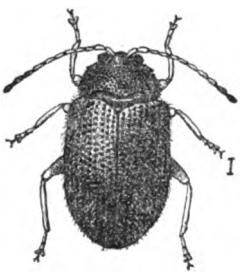

Fig. 27.—Cucumber Flea Beetle—much enlarged. (Chittenden, Bul 19, Bur. of Ent., U. S. Dept. of Agr.)

Other Flea Beetles.—Several different species of flea beetles occur at times, and injure cabbages, turnips, potatoes, beans and many garden plants. The larvæ of most species feed on the roots of Jimson or other common weeds. The beetles all get their name from their ability to jump, due to thickened and muscular hind legs like those of the grasshopper.

REMEDIES.

Protective covers, poison and repellent sprays, and powders, and in fact all methods of control suggested above against the striped cucumber beetle are effective against flea beetles.

Pickle Worm *(Diaphania nitidalis,* Cramer).

Growers of cucumbers and cantaloupes need no introduction to this troublesome pest that bores into cucurbits, rendering them unfit for table use or for market. The injury is caused by the larvæ. This borer is frequently called the melon worm or cantaloupe worm, but we will consider it as the pickle worm because a closely related species is now known as the melon worm. (See p. 57).

DESCRIPTION.

Eggs and Larvæ.—The eggs are generally laid in masses in blooms or tender buds. They are at first white, but change to yellowish green before hatching into small whitish worms. When grown the larvæ are yellowish green in color, about three-fourths of an inch long, and have eight pairs of legs.

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Pupæ.—Light silken cocoons are spun in a fold of a leaf of the food plant, or on weeds close by, and here the pupæ are formed, changing later to adult moths.

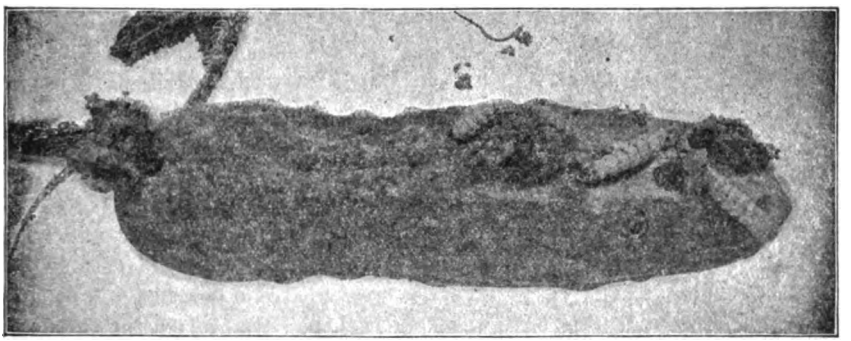

FIG. 28.—Pickle Worms working on cucumber. (Quaintance, Bul. 45, Ga. Exp. Sta.)

Parent Moths.—The moths have a wing expanse of about an inch; the color is yellowish brown, marked with yellow areas. The body terminates in a prominent brush like that of the melon worm (Fig. 37).

LIFE HISTORY AND HABITS.

The average life cycle of the pickle worm was determined by Quaintance[1] in 1901 as being from 24 to 27 days, showing that there may be at least four or more broods each year. The winter is passed in the pupal stage, always above ground in weeds or rubbish, which allows the gardener a chance of destroying great numbers by clean culture. The moths are nocturnal, hiding during the day. It seems that the first ones emerging from the over-wintering pupæ are somewhat late, appearing when the cucumbers or cantaloupes are well started into growth. The young larvæ may feed in opening buds, or at the base of the leaves, but soon attack the fruit. The greatest injury of course comes from their boring into the fruit, this being exaggerated by their habit of passing from one fruit to another. A great preference is shown for the blooms of squash (Fig. 29), and this may be made use of in protecting the cantaloupes and cucumbers as stated under remedies.

REMEDIAL MEASURES.

Very early planted cucumbers and cantaloupes for home or market use may escape injury from this pest, owing to the late appearance of the moths. Late plantings may be seriously injured, and there seems

[1] Georgia Expt. Sta. Bul. 54.

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to be no absolute remedy to suggest. Trap crops, clean culture, and poisoning will all help to lessen the injury.

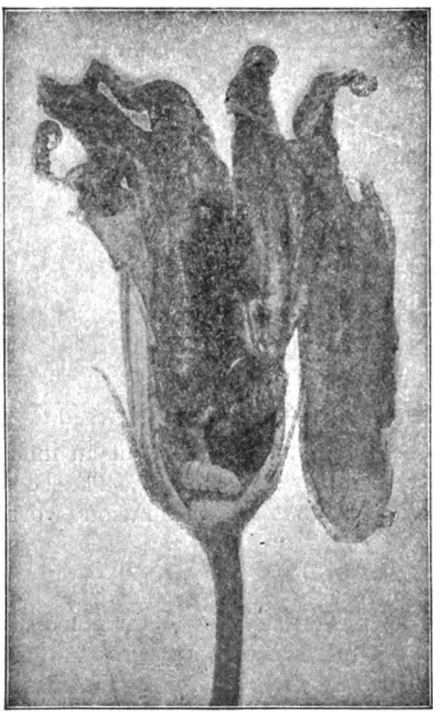

FIG. 29.—Pickle Worms feeding in squash blooms. (Quaintance, Bul. 45, Ga. Exp. Station).

Poison.—Dusting young plants with lime dust and Paris green may serve to poison some young larvæ that feed in the buds and flowers before entering the fruit.

Trap Crop.—Squash plants started early and planted among and near the crop to be protected are of great value if properly managed. The pickle worm larvæ feed freely in the squash blooms, and when this plant is used as a trap the infested blooms must be regularly gathered at least once a week and carefully destroyed to prevent any larvæ from maturing. Quaintance found that this crop offers very great protection, and when adopted squash seed should be planted every two or three weeks in order to furnish an abundance of blooms while the cucumbers and cantaloupes are developing. The squash plants might be poisoned also as a further protection.

Destroying Infested Fruit and Over-wintering Pupæ.—All infested fruit should be gathered and fed to hogs or otherwise destroyed to kill the larvæ within. As soon as the crop is gathered, rake up and burn the vines, together with all weeds and rubbish, to destroy any larvæ and pupæ that may be present. Deep plowing directly after the crop is gathered will no doubt stop further increase, and as another safeguard it is best to practice rotation of crops.

INSECTS AFFECTING THE EGG-PLNT.

Egg-plants are not subject to serious injury from insect attack, but some minor damage may occur each year. Some insect pests that may be expected are mentioned below:

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APHIS (Plant Lice).—(See under Cabbage Aphis, p. 17).

COLORADO POTATO BEETLE.—(See under Potato Insects, p. 49).

CUTWORMS.—(See under Bean Insects, p. 11).

FLEA BEETLES.—(See under Cucumber Insects, p. 44).

HARLEQUIN BUG.—(See under Cabbage Insects, p. 18).

INSECTS AFFECTING THE ONION.

CUTWORMS.—Onion sets are liable to be seriously thinned out by cutworms, hence land on which onions are to be set should be carefully prepared, and freed as far as possible, from these pests by the use of poisoned baits as recommended on p. 12. When onions are grown in the field from seed an abundant supply should be planted to insure a stand, but the use of poisoned bait previous to sowing the seed should not be neglected.

ONION MAGGOT *(Pegomyia ceparum,* M.).

When plants in the onion beds commence to turn yellow, wilt, and die, from no apparent exterior cause, white maggots in the roots may be looked for.

As the life history and habits of this insect are so nearly the same as the cabbage maggot, the reader is referred to the description on p. 28.

Remedy.—In addition to the remedies suggested against cabbage maggots, gardeners may make good use of a carbolic acid emulsion, recommended by Slingerland,[1] whose formula is as follows:

Dissolve one pound of soap in one-half gallon of water, and thoroughly emulsify with one pint of crude carbolic acid. For use take one part of the emulsion to fifty parts of water.

This emulsion should be applied with a spray pump around onion plants, after first removing the surface soil. It is said to kill the maggots and also repel the parent fly from laying eggs.

Unleached ashes scattered over the beds just after the onions have come up is also said to repel the parent flies.

Infested fields should not be planted to onions the following year, and new seed beds should be placed as far away as possible.

INSECTS AFFECTING PEAS.

PEA WEEVIL *(Bruchus pisorum,* Linn.).
(And Other *Bruchus* spp.).

Belonging to the same genus as the Bean Weevil, but differing considerably in life history, the pea weevil *(B. pisorum)* is a common

[1] N. Y. Cornell Expt. Sta. Bul. 78.

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pest in stored peas. This species is a little larger (Fig. 30) than the bean weevil described on p. 15 and illustrated in Fig. 7. They differ materially, however, in the number of annual generations, for the pea weevil has only one, while the other may have several. Furthermore, only one larva of the pea weevil invades a single pea, and always gains entrance while the peas are green in the field. In other words, the pea weevil does not breed in dried peas, like the other species that have been mentioned.

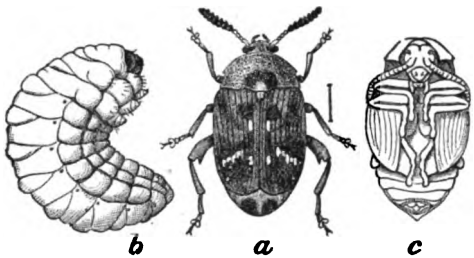

FIG. 30.—Pea Weevil, *Bruchus pisorum*: *a*, beetle; *b*, larva; *c*, pupa—much enlarged. (Chittenden, Yearbook, 1898, U. S. Dept. of Agr.)

The 4-spotted bean weevil (Fig. 8) may infest peas or beans, and unlike the common pea weevil, this species will breed in dried peas, producing successive generations like the bean weevil, hence any remedy against pea weevils must be one that will destroy all species present.

REMEDIES.

Fumigation.—If only the pea weevil *(Bruchus pisorum)*, that does not attack dried peas, were present, fumigation of peas would not be necessary. Simply placing them in perfectly tight receptacles until the adult weevils died would be sufficient. This condition may not occur, however, so we must prepare to fumigate to kill weevils whenever present.

Fumigation is the best remedy known, and carbon bisulphid is the material usually used. This clear, colorless, foul smelling liquid will kill the weevils, both larvæ and pupæ, but not the eggs. It is used, at the strength of one teaspoonful to a cubic foot of space, by placing the infested beans or peas in a perfectly air-tight receptacle, such as a large earthen jar, exposing the liquid on top in a shallow dish, and leaving the chamber closed for twenty-four hours. The liquid soon evaporates and the fumes, which are heavier than air, readily penetrate to the bottom.

Much loss might be prevented if gardeners would practice fumigation of peas and beans when first stored, but even when that is done they should be treated again if any weevils are observed later. As several broods may develop and weevil eggs may be present almost any time, fumigation must usually be repeated two or three times. The reader should refer to p. 40 for further information about carbon bisulphid and precautionary measures to be observed.

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Uninfested peas or beans, if stored in perfectly tight receptacles, will remain free from weevils.

To insure getting good seed for planting, pour them in water, when the infested ones will float and may be discarded.

INSECTS AFFECTING IRISH POTATOES.

This valuable vegetable is subject to the attack of leaf-eating insects, such as Colorado Beetles, Flea Beetles, etc., and the tubers may be damaged by wireworms and white grubs. These pests, together with the stalk borer and others, must be fought successfully if potato growing is made profitable.

Colorado Potato Beetle *(Leptinotarsa 10-lineata*, Say.).

This common potato pest is well known and frequently referred to as the potato bug, though the name beetle is more appropriate. It has been given the name Colorado potato beetle because of its being native to Colorado, where it formerly fed upon wild weeds belonging to the same genus as the potato plant. The Irish potato seemed to be much preferred by this insect, and when that vegetable was introduced it was speedily attacked.

Colorado potato beetles were first seriously injurious to potatoes in 1855, in Colorado, and since then have spread to the East and North, until now they occur in practically all of the potato growing sections of the United States and Southern Canada. Its natural spread was undoubtedly hastened by the parent beetles being shipped with potatoes. At the present time it appears to be omnipresent, for the potato patch can not be located where the beetles may not appear. For this reason the practice of rotating crops, so beneficial against certain other insects, does very little good in this case.

DESCRIPTION AND HABITS.

Parent Beetles.—It has been said that these beetles perch themselves on clods of earth and await the sprouting of potatoes in spring. This is almost literally true, for the adults pass the winter in protected places, and are among the first to appear in spring.

The beetles are ochre-yellow in color, with ten longitudinal black lines on the wing covers (Fig. 31). They do considerable damage by feeding on the foliage.

Eggs.—The eggs are deposited in flat clusters of fifty or more, on the under sides of the leaves. They are conspicuous orange colored. Each female may lay from six hundred to one thousand eggs.

Larvæ or "Bugs."—The soft bodied, reddish, hump-backed creatures, commonly called bugs, are voracious feeders, causing much

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more damage than the adults. In four to five weeks, they attain full growth after eating an enormous quantity of food, and then drop from the plants, enter the earth and form a smooth, oval cell (Fig. 31).

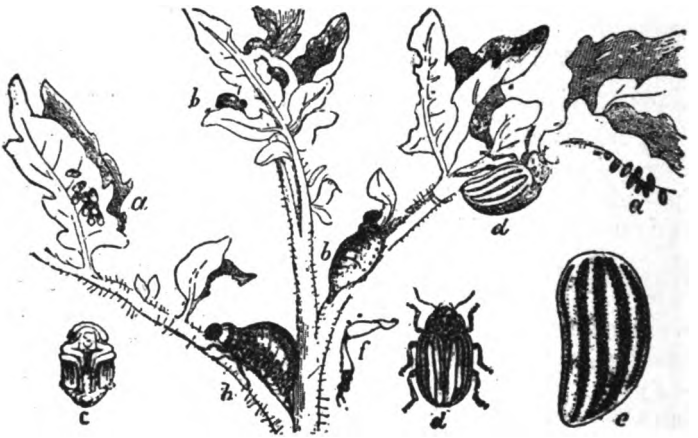

FIG. 31.—Colorado Potato Beetle: *a*, eggs on leaf; *b*, small and grown larvæ; *c*, pupa; *d*, adult beetle; *e*, enlarged wing-case of adult; *f*, enlarged leg of adult. (Riley, Missouri Reports).

Pupæ.—In the earthen cells the pupæ pass a motionless life for ten days to two weeks, and then transform to the parent beetles.

Generations.—There are probably four generations each year in North Carolina, the last beetles passing the winter in hibernation.

REMEDIES.

The voracious feeding habits of this pest, coupled with the power of the potato plant to withstand arsenical poisons, offers us a reliable remedy in the poison applications.

Arsenicals.—Paris green or arsenate of lead applied as a liquid spray is a perfect remedy. The former may be used at the greatest strength recommended on page 60 and the latter at the usual strength.

Dry Paris Green Mixture (See p. 60) may be dusted on while wet with dew or just after a rain by means of a good powder gun, or through a cloth sack, or a tin can with the top perforated like a pepper shaker. These poison applications will certainly control the Colorado potato beetles, but the grower should watch carefully for the first appearance of egg masses, and then be prepared to apply the poison to kill the young larvæ before the plants are defoliated. It is just as easy to poison the bugs before the foliage is injured—and certainly more economical.

No Danger From Arsenical Sprays on Potatoes.—The writer has met a few people who feared to apply the Paris green to potato plants,

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thinking that the tubers would absorb the poison from the foliage. There is absolutely no such danger, and practically no danger to the persons applying the poison.

Bordeaux Mixture and Paris Green.—We would particularly advise the use of Paris green in Bordeaux mixture (See p. 61), as it helps to keep the plants free from disease, and the poison so applied is not readily washed off by rains. Arsenate of Lead may be applied in the same manner.

Three-lined Leaf Beetle *(Lema 3-lineata,* Oliv.).

This somewhat common potato pest is closely related to the Colorado beetle, but differs in size and color. The beetles are about one-fourth inch long, yellow in color, with three black stripes on the wings, resembling the striped cucumber beetles mentioned on p. 42. The larvæ are dirty yellow and may be recognized by the habit of covering the body with their own excrement. The eggs are orange colored, usually laid in rows along the mid-rib on the lower sides of the leaves.

When present these insects may be controlled by the remedies suggested against the Colorado beetle.

Flea Beetles *(Several Species).*

These small jumping beetles, usually black in color, riddle the leaves with small holes, but their work may be prevented by thoroughly spraying the plants with Bordeaux and Paris green mixture. The cucumber flea beetle, mentioned on p. 44, often attacks the potato plant. Poison dust sprays act both as a repellent and poison to these little creatures.

Potato Stalk Borer *(Trichobaris trinotata,* Say.).

As its name implies, the insect lives in the larval or grub stage in the stalk, boring through the heart, and when several are present, they severely weaken and generally kill the infested plants. The presence of only one or two is seldom noticed.

DESCRIPTION AND HABITS.

Adult.—The parents of the stalk borers are small, greyish weevils, about one-sixth inch in length, and having a strong, curved snout. They hibernate during winter, usually appearing early in spring to deposit eggs in the potato stalks. Otherwise they cause no apparent damage.

Larvæ.—Usually called grubs, are white or yellowish in color with brown, horny heads, and attain a length of about one-half inch. When grown they change to pupæ in cocoons in the stalk.

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Life History.—There are two generations each season, the adult of the first appearing about the middle of July, while the adults of the later brood appear during August or September, and hibernate during winter. (See Fig. 32 for illustration of this insect.)

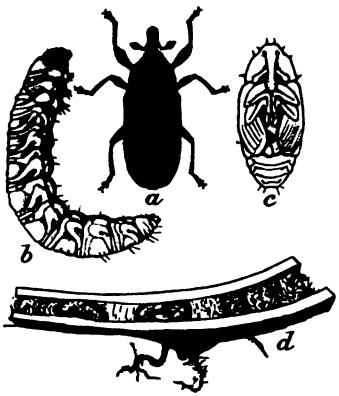

FIG. 32.—Potato Stalk Borer: *a*, beetle; (weevil); *b*, larva (borer); *c*, pupa—five times natural size; *d*, section of potato stalk opened to show larva and pupa *in situ*. (Chittenden, Bul. 33, Bur. of Ent., U. S. Dept. of Agr.)

REMEDIAL MEASURES.

It appears impossible to suggest a direct method for killing the borers in the stalks without destroying the plants, hence every effort should be directed toward keeping them from reaching the adult beetle stage, and thus prevent them from being numerous during the succeeding season. Infested plants, detected by their wilted appearance, should be pulled up and burned. After the potato crop is gathered all vines in the infested fields should be raked together, dried a few days, and then burned.

It is known that this borer breeds in the stem of the egg plant and wild plants, such as horse nettle, bull nettle, jimson weed, and many *solanaceous* plants. When these occur around infested potato fields they should be cut and burned, if possible, while the borers are in the stems, and thereby prevent the development of beetles.

WHITE GRUBS OR GRUBWORMS.

We will discuss white grubs under the head of "Potato Insects," though in reality they are often as injurious, and sometimes more so, to strawberries, corn, small grains and many tuberous rooted vegetables such as beets, turnips, etc. In fact most garden crops are injured at times by white grubs, which are more or less common in all localities. It is evident that these insects formerly subsisted on grass roots in the wild prairie lands, being native to this country, and turned their attacks to cultivated crops when deprived of their natural food by the cultivation of lands in which they lived. There are a large number of species of white grubs, some being feeders on decaying vegetable matter, manure, etc., and hence not injurious, while others subsist on the roots of growing plants.

GENERAL DESCRIPTION.

White grubs, in general, may be described as having thick bodies, and hard, horny heads, behind which are three pairs of true legs end-

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ing in claws, while their abdomens are usually distinctly enlarged near the caudal ends (Fig. 33, e). They lie in a curved position, as shown in the figure. Some species get to be nearly two inches long,

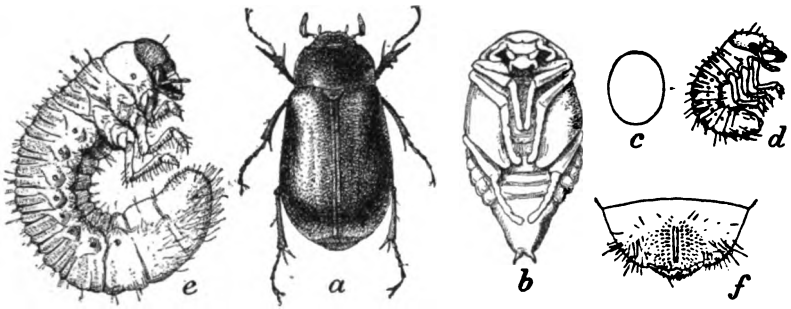

FIG. 33.—White Grub, *Lachnosterna arcuata*: *a*, beetle; *b*, pupa, *e*, larva—all enlarged one-fourth. (Chittenden, Bul. 19, Bur. of Ent., U. S. Dept. of Agr.)

while many are smaller. Practically all the most injurious forms belong to the genus *Lachnosterna*.

Parent Beetles.—The parents are called May or June beetles, mostly shining brown in color and quite large, being known by their habits of flying into houses attracted by the lights at night. The beetles occasionally cause much injury to pecan trees and fruit trees by eating the developing buds.

LIFE HISTORY AND HABITS.

The eggs are deposited in sod lands, weedy places, strawberry beds, especially if the latter are weedy, and young grubs feed on the roots of almost any available plants. The eggs are laid from May to July, and the grubs require from two to three years to mature, this depending on the species.

It will be seen that land once infested may remain so continuously, and when disturbed by plowing, destroying the crop, strawberries, grass or whatever was on the land, the grubs must feed on the roots of the crops following. If potatoes are planted on sod land or old strawberry beds, they are liable to be seriously damaged by these insects, and the same would be true of most other vegetables.

When mature, the grubs transform to pupæ in earthen cells, and about August or September change to the parent beetle, which may remain in the cell all winter.

REMEDIES AND PREVENTION.

Insecticides.—These are not practicable in the writer's opinion, though liberal applications of Gas Lime or kerosene emulsion have been used on lawns with some success.

Rotation.—This is another case where an ounce of prevention is

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worth a pound of cure. Land known to be infested with white grubs should be sown in clover or some crop least liable to be injured by these insects, at least two years before planting in potatoes or any other tuberous vegetable. Corn land is liable to be infested, and here rotation is valuable. Sod land should never be planted to vegetables the first year after plowing. The rotation should be planned so that the land may be thoroughly plowed each fall or winter.

Fall Plowing.—This will undoubtedly kill some grubs by exposing them as prey to birds and fowls and by leaving them exposed to the winter's cold. By following fall plowing with a cross plowing or harrowing during winter when the condition of the land will permit, better results will be obtained.

Domestic Animals.—Chickens and turkeys should be encouraged to follow the plow, as they will pick up great numbers of all kinds of insects. Hogs delight to root for white grubs, and if turned into the garden and encouraged to root by scattering a little corn on the ground, they will render valuable service.

INSECTS AFFECTING THE SQUASH.

Squash Bug (*Anasa tristis*, DeG.).

Here we have another injurious sucking insect, and one that seems to inject a poison into the plant the same as as is the case with the Harlequin bug on cabbage. The name stink-bug is often applied to this insect, and to several related forms because of their disagreeable odor.

DESCRIPTION AND HABITS.

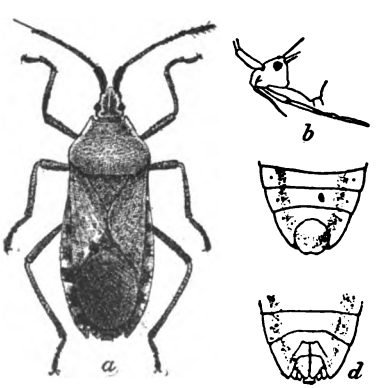

Fig. 34.—Adult Squash Bug: Twice natural size. (Chittenden, Bul. 19, Bur. of Ent., U. S. Dept. of Agr.)

Adult Bugs.—These bugs are very generally known, but may be briefly described as being a little over one-half inch long (Fig. 34), dirty blackish brown above, and mottled yellowish beneath, the head bearing a long jointed beak that lies between the legs when not in use. They are nocturnal in their habits, and hide during the day under sticks, leaves, etc.

Eggs and Nymphs.—The brownish eggs are laid in irregular rows on the leaves, and hatch into small awkward looking creatures. These young, called nymphs, generally feed for a time in groups, and increase in size by successive molts, gradually developing wings. A

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dozen nymphs may seriously injure a small squash or melon plant, by the combined effect of loss of sap and poison injected.

Life History.—The adult squash bugs pass the winter in protected places, under rubbish in or about the gardens, or in fence corners, etc., appearing early in spring to deposit eggs. There may be several generations each year.

REMEDIES AND PREVENTION.

Hand Picking.—The first bugs appearing in spring may be collected by hand to prevent their depositing eggs. This practice is advisable all through the spring and summer, when plants are not otherwise protected.

Cover Protection.—Young plants may be protected by methods recommended on p. 43 under Cucumber Insects.

Trapping.—Trap plants started very early, planted indoors in strawberry baskets, if desired, and transferred to the garden, will be found very valuable. The bugs will collect on such plants and may be picked off by hand together with the egg masses. Bugs may also be trapped at all times under shingles, boards, or cabbage leaves. After feeding at night, they will hide under these traps, from which they should be collected each morning, particularly during early spring.

Spraying.—Poison sprays are obviously useless against this sucking insect, but kerosene emulsion of a strength of 10 per cent will kill the young nymphs when feeding in groups. Repellent sprays or powders (See p. 43) are of some value.

Clean Culture.—Burning all rubbish and old plants, both after the crop is gathered and during fall or winter, will do much toward preventing the adult bugs from hibernating successfully.

Squash Vine Borer (*Melittia satyriniformis*, Hbn.).

Damage from this insect is caused by the larvæ boring into the stalk, sometimes resulting in death of the infested stalk, and always causing a loss of vitality. Squash and pumpkin are the favorite food plants, but melons and cucumbers may be attacked.

DESCRIPTION.

Parent Moths.—The moths as described by Quaintance[1] have forewings opaque, shining olive brown in color, and transparent hind wings bordered by a narrow fringe of scales. The body is about three-fourths of an inch long, with a wing expanse of nearly one and

[1] Georgia Expt. Sta., Bul. 45, p. 47.

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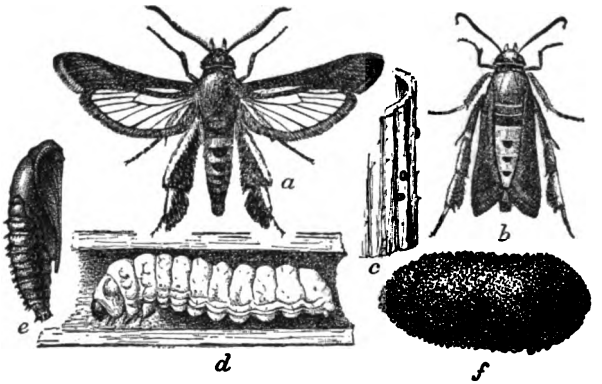

FIG. 35.—Squash-Vine Borer. *a*, male moth; *b*, female moth, wings folded; *c*, eggs on stem; *d*, larvæ; *e*, pupa; *f*, pupa cell—all one-third enlarged. (Chittenden, Cir. 38, Bur. of Ent., Dept. of Agr.)

one-fourth inches (Fig. 35, enlarged).

Larvæ and Pupæ.—The borers are about one inch long, whitish in color and grub-like in form. When grown, they leave their burrows and spin tough silken dirt covered cocoons (Fig. 36) near the base of the plant from which they emerged. In this cocoon the larva changes to a pupa and eventually to an adult moth, which escapes through the end, as illustrated in Fig. 36.

LIFE HISTORY.

Observations on the life history of this insect, made in Georgia by the writer, showed that the pupæ stage was from three to four weeks, and that adults of the first brood appeared about the last of June. The second and last generation pass the winter in cocoons, changing to moths in spring about the last of April. These dates are probably a little too early for North Carolina conditions.

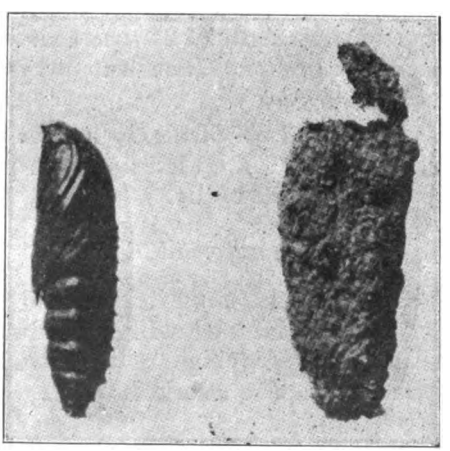

FIG. 36.—Pupa and empty cocoon of squash-vine borer—; twice natural size. (Photo. by the author.)

TREATMENT.

The presence of borers may be detected by the accumulations of yellow excrement, cast out from the burrows about the base of the plants. Early in June this is frequently quite noticeable, and, when detected by the gardener, the borers should be carefully searched for and removed. This may be done without much additional injury to the plants, and is the only

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direct remedy. The borers of the first brood should be destroyed if possible.

After the crop is gathered the vines, root and all, should be pulled and burned to destroy any borers that might be within. As some borers of the second brood are liable to form cocoons before the plants are removed, deep fall plowing is advisable. This, coupled with prompt destruction of infested plants before the borers escape, should keep the pest reduced to insignificant numbers.

Melon Borer *(Diaphania hyalinata,* Linn.).

Closely related to the borer known as the pickle worm, described on p. 44, this destructive pest causes much damage by eating off the soft rind and boring into the squash, melon, etc. It differs from the pickle worm mainly in the habit of eating the foliage more freely and is therefore more easily controlled.

DESCRIPTION.

Parent Moths.—This is quite a beautiful moth described by Quaintance[1] as having wings of pearly iridescent whiteness, with a border of brownish black. The body color is white and brown, and the abdomen terminates in a large movable brush of elongated scales. The body is about three-fourths of an inch long and wings expand about one and one-fourth of an inch (Fig. 37, enlarged).

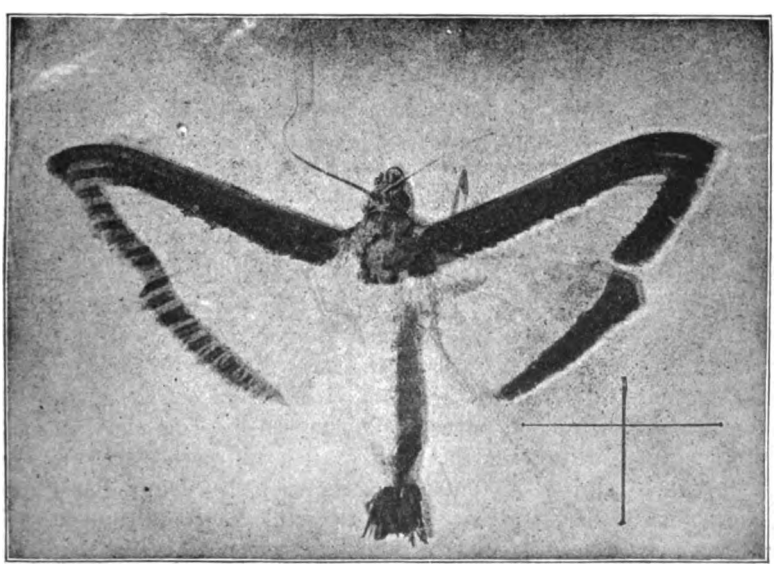

Fig. 37.—Moth, or parent of the Melon Worm: Much enlarged. (Qualntance, Bul. 45, Ga. Expt. Sta.)

[1] Georgia Expt. Sta., Bul. 45, p. 45.

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Eggs and Larvæ.—Eggs are placed singly on the lower surface of the leaves, and hatch into active caterpillars, which when grown are slightly longer than pickle worms. They are of a pale greenish yellow color and possess a black head.

LIFE HISTORY AND HABITS.

The life history of this borer is nearly the same as the pickle worm. The greatest difference in habit is that of feeding on the foliage more than the pickle worm, and this gives the gardener an opportunity to make use of poison sprays. The melon borer seems to thrive best during rainy seasons.

REMEDIES.

Spraying is quite effective against the young borers that feed on the foliage. Paris green-lime mixture, Bordeaux-Paris green mixture, or arsenate of lead may be used. The gardener should watch carefully for the first brood of melon worms and be prepared to use the arsenical sprays quickly and thoroughly. Infested fruit should be fed to hogs or otherwise destroyed.

All the preventive measures recommended on page 45 against the pickle worm should be used against the borer, except the method of using squash blooms as traps.

INSECTS AFFECTING TOMATOES.

Cutworms.—(See under Bean Insects, p. 11).

Flea Beetles.—(See under Potato Insects, p. 51).

Potato Beetles.—(See under Potato Insects, p. 49).

Tomato Fruit Worm *(Heliothis obsoleta).*

This is the same as the corn ear worm and the cotton boll worm. Under Corn Insects, p. 37, the reader will find a full description and also cultural methods of control. It is true that this is a difficult pest to fight, unless the gardener will study the habits of the worm, and learn how best to make use of corn as a trap crop, for there is no good remedy except to pick them off by hand. Corn as a trap crop, unless properly managed so as to destroy the worms that attack it, may serve only to increase the numbers of this pest.

Thorough spraying of tomato plants with Bordeaux-Paris green mixture, usually used against flea beetles and the green tomato worm, may result in poisoning some of the fruit worms. This should not be depended upon, however, for the worms eat only a small area of the surface of tomatoes.

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Tomato Horn Worm *(Phlegethontius celeus,* Joh.).

This conspicuous green worm is sometimes abundant enough to cause noticeable injury and occurs also on tobacco, and on that plant it is a very serious pest. This is the larvæ of a large, narrow-winged moth, belonging to the family *Sphingidæ* or Sphinx Moths.

Fig. 88.—Tomata Horn Worm, *Phlegethontius celeus: a*, adult moth; *b*, full-grown larva; *c*, pupa—about two-thirds natural size. (Howard, Farmers' Bul. 120, U. S. Dept. of Agr.)

DESCRIPTION.

Larvæ.—Full grown worms are from three to four inches long, dark green in color, with oblique V-shaped white lines on each side of the body. The caudal end bears a prominent, long, sharp-curved horn that is quite characteristic. A closely related species of horn-worm, having straight white oblique lines on each side of the body is almost equally common.

Moths.—The moths have large, powerful wings, narrow compared to their length, and a robust body. The wings are brownish gray in general color with wavy markings and expand about four inches. The abdomen is marked on each side by five orange colored spots bordered with black.

REMEDIES.

Small fields of tomatoes, or especially a few garden plants, may be protected by picking the worms off by hand. Arsenical poison sprays used in connection with Bordeaux mixture is advisable, for this latter is of great value alone as a fungicide. Arsenical sprays may be used up to within ten days of the time the fruit ripens without danger of poisoning persons who eat the tomatoes.

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FORMULAS AND DIRECTIONS FOR PREPARING SPRAY MIXTURE.

FOR BITING INSECTS.

Paris Green (as a liquid spray).

Paris Green .....1 pound
Lime .....2 pounds
Water .....100 to 200 gallons
Or Bordeaux mixture.....100 to 150 gallons

(See formula, next page.)

To prepare.—The combination of Bordeaux mixture and Paris green is often preferable to the simple water mixture with lime; but no matter what is used as a carrier for the poison, it should first be made into a thin paste with a small amount of water. This will prevent lumping and insure an even distribution of the poison in the mixture. When Bordeaux is used it is unnecessary to employ the extra two pounds of lime, but this should always be added to the simple water mixture. The lime unites with any free arsenic that may be present in Paris green, preventing burning of foliage that might otherwise occur.

Paris green, if absolutely pure, is entirely insoluble in water, but most commercial grades contain some water-soluble arsenic, the burning effect of which is overcome by lime. Paris green is really a very fine crystalline powder, and must therefore be held in suspension by constant agitation.

Plants with tough resistant foliage like potatoes and cabbage may be sprayed with one pound Paris green in 100 gallons of water, but tender plants such as tomatoes, beans, and celery, should be given a more diluted mixture.

Paris Green (in dry form).

Mix with from ten to fifty parts of cheap flour, land plaster, sifted air-slaked lime, ashes or fine dust and dust evenly over the plants by means of a cloth sack, pepper shaker arrangement or dusting machine.

Green Arsenoid.

This is often substituted for Paris green, and may be used in the same proportion, but should never be used as a liquid spray without the addition of lime. Green arsenoid is lighter in weight, not crystalline in form, and remains in suspension longer than Paris green, but otherwise it has no advantage unless it can be purchased at less cost.

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Arsenate of Lead.

Acetate of Lead *(Sugar of Lead)*	11 ounces
Arsenate of Soda	4 ounces
Water	50 gallons

This is a formula for home-made arsenate of lead, prepared by dissolving the acetate of lead in one gallon of water, and the arsenate of soda in two quarts of water in a separate vessel. It is best to use wooden buckets. When the two solutions are poured together a fine, white precipitate is formed. This makes a stock solution ready to dilute with 50 gallons of water.

The advantages of arsenate of lead over Paris green and green arsenoid are: (1) greater adhesive quality; (2) remains in suspension with very little agitation; and (3) seldoms injures foliage. It is generally claimed that it will not burn or injure the tenderest foliage, but this is not true, although it is perfectly safe to use on most garden vegetables.

Arsenate of lead is now manufactured rather extensively and is put up and sold as a dry powder or paste. At wholesale prices the manufactured product is about as cheap as that prepared at home, and somewhat preferable, because of its always being ready to mix with water.

Bordeaux Mixture and Arsenicals.

Bordeaux mixture	50 gallons
Containing one of the following:	
Paris Green	1-3 to 1-2 pound
Arsenate of Lead	3 pounds
Green Arsenoid	1-3 to 1-2 pound

It is frequently desirable to use arsenicals in Bordeaux mixture because, in addition to killing the insects, the plants should be protected from leaf diseases. Bordeaux mixture is a great help towards keeping plants healthy. Furthermore, the poison is made to adhere longer, and is very much less liable to injure the foliage when used in this manner.

Bordeaux Mixture.

Bluestone (Copper Sulphate)	4 pounds
Lime, fresh unslaked	6 pounds
Water	50 gallons

To prepare.—Dissolve the bluestone in 25 gallons of water in one receptacle, and slake the lime in another, and dilute to 25 gallons. Do not pour the solutions directly together, but take a bucketful of each and pour these simultaneously into a barrel or spray tank. As

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the solutions unite a fine blue precipitate is obtained, and the resulting mixture will not settle as rapidly as when the two solutions are mixed by pouring one directly into the other.

Many writers advocate making Bordeaux for general use with 6 pounds of bluestone and 6 pounds lime, but this is apparently stronger than is necessary, and at the present price of bluestone, is rather expensive.

Adhesive Resin Wash.

With a few plants, like cabbages and collards, which have very smooth foliage, difficulty is often experienced in making poison mixtures adhere. To overcome this difficulty, the following is suggested:

Stock Solution	Pulverized Resin	5 pounds
	Concentrated Lye	1 pound
	Fish Oil	1 pint
	Water	5 gallons

To prepare.—Place the oil and resin in one gallon of water and boil until the resin is thoroughly softened. Dissolve the lye in a separate vessel and add slowly to the resin mixture, stirring constantly until well mixed. Then add four gallons of water and continue the boiling until the resulting mixture will mix readily with cold water.

DIRECTIONS FOR USING.

Resin Mixture *(Stock Solution)*	1 gallon
Water	16 gallons
Milk of Lime (2 pounds unslaked lime)	3 gallons
Paris Green or Green Arsenoid	1-4 pound

To prepare.—Add water to the stock solution and mix thoroughly; then add the milk of lime, and then the Paris green or green arsenoid. The order of mixing should not be changed, or a heavy precipitate will form that will clog the spray pump and nozzle. The stock solution may be kept on hand, but the diluted mixture must be freshly prepared when used.

Hellebore.

Hellebore acts both as an internal and contact poison. It is used against soft-bodied caterpillars, such as cabbage worms, in liquid form, 1 ounce in 3 gallons of water; or mixed, dry, with four parts of cheap flour or road dust. It loses its strength when exposed and must be applied every two or three days as long as the worms are present. This is not very valuable for use except on vegetables that are nearly grown.

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FOR SUCKING INSECTS.

Kerosene Emulsion.

Stock Solution.

Hard Soap	1-2 pound
Or Soft Soap	1 quart
Water	1 gallon
Kerosene	2 gallons

To Prepare.—Dissolve the soap in one gallon of boiling water. Remove from the fire and add two gallons of kerosene and agitate the mixture violently for fully ten minutes. As the kerosene and soap solutions combine, a smooth, creamy emulsion will result, and when properly mixed, will remain for weeks without separating. The emulsion is best prepared by using a small force pump, throwing a small stream and pumping the mixture back into itself for ten minutes. Soft water should be secured, but a little common lye may be used to "soften" water that is naturally too hard.

For convenient reference the proper amount of water used in diluting the stock solution to a certain strength is given below:

For 5 per cent emulsion dilute with 37 gallons of water.
For 10 per cent emulsion dilute with 17 gallons of water.
For 15 per cent emulsion dilute with 10 1-3 gallons of water.
For 20 per cent emulsion dilute with 7 gallons of water.

Tobacco Products (as a liquid spray).

Tobacco leaves or stems	2 pounds
Water	4 gallons

Boil for about 2 hours.

Tobacco water, made by the above formula, should be used at full strength. It is valuable for killing plant lice, and as a repellent against flea beetles, cucumber beetles, etc.

Tobacco Products (in dry form).

Tobacco dust is of some value as a repellent when applied liberally to the foliage of small garden plants.

Soap Solutions.

Whale oil soap, made from refuse fish oil, is a valuable contact poison for killing plant lice. The potash soaps are preferable to soda soaps. Common potash (washing or laundry) soap may be used with success at a strength of 1 pound in 3 or 4 gallons of water, and is just as effective against common garden plant lice as whale oil soap or dilute kerosene emulsion. This gives a little better result than tobacco water.

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Pyrethrum.

Pyrethrum, also known as Buhach, Dalmation powder, and Persian Insect Powder, is poisonous to most insects, but harmless to higher animals. The powder gets into the breathing pores, acting by its suffocating effects, and it also contains an essential oil that kills by contact. As this oil evaporates rapidly when exposed to the air, pyrethrum must be kept in air-tight receptacles until used. Pyrethrum kept in open boxes or loose drawers is very nearly worthless.

Pyrethrum in dry form is used pure or diluted with flour, and will kill cabbage worms and most soft-bodied insects. It must be applied every two days while the insects are numerous.

Pyrethrum in solution is used by mixing 1 ounce in 2 gallons of water. In this form it will not injure the tenderest foliage.

Tobacco Fumigating Papers.

As stated on p. 41 tobacco fumigating papers have been carefully tested in Texas as a remedy for lice on cucumbers, cantaloupes, etc. The brands that have been well tested are Nico-fume Paper, To-bak-ine and Aphis Punk.

These papers are prepared so that they will burn rapidly and are generally lighted in tin cans under the fumigating frames, which are described on p. 41. Old tin cans with perforations near the bottom edge answer the purpose very well. The actual time required to kill the lice will vary, but may be easily determined by experience.

SPRAY PUMPS AND EQUIPMENT.

There are many forms of spray pumps on the market, some good, and some almost worthless for the purpose of spraying garden plants. Good, serviceable spray pumps fitted with suitable hose, extension rod, and nozzle, are quite necessary for the proper application of some materials recommended against garden insects. Readers who desire information on the subject of spray pumps and equipment should send for Bulletin 193 of the North Carolina Experiment Station, and should also write to a number of spray pump manufacturers for catalogues. Persons who have never used spray pumps will do well to investigate the merits of the different makes before making a purchase. The names of Spray Pump Concerns are listed in the Bulletin mentioned above.

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Bulletin 198 June, 1908

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND

MECHANIC ARTS

WEST RALEIGH

HANDLING AND MARKETING OF MILK AND CREAM

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N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

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CONCLUSIONS.

The cottonseed hulls and shredded corn stover fed in this experiment were of equal value as milk and butterfat producers. It should be stated, however, that the hulls were of good average quality, while the stover was below average, especially in palatability.

It is a wasteful practice for farmers to purchase cottonseed hulls at $8.00 per ton when shredded corn stover of inferior quality can be fed with equally satisfactory results.

Rolled oats constitute an excellent substitute for milk in calf feeding. They are highly relished by young calves and materially reduce the cost of feeding where no skimmed milk, or an insufficient amount, is available for the purpose.

The results indicate that 4.4 cents worth of rolled oats (the cost of one pound) when fed in moderate quantity, is nearly equal to one gallon of whole milk.

With corn stover as the exclusive roughage, corn meal and dried brewers' grains have practically equal feeding value when supplemented by a grain ration consisting of one-half cottonseed meal and one-quarter corn meal.

With most cows, the continuous feeding of corn stover as the exclusive roughage results in too rapid shrinkage in milk flow for best returns.

The results of these experiments incline us to recommend to dairymen who are feeding much corn stover, a grain ration consisting approximately of one-half cottonseed meal, one-quarter corn meal, and one-quarter dried brewers' grains, or wheat bran or some other similar light, fluffy, concentrate, depending upon the relative market price of these feeds.

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COMPARISON OF COTTONSEED HULLS AND SHREDDED CORN STOVER FOR MILK PRODUCTION.

By JOHN MICHELS, Dairy Husbandman.

Statistics recently gathered by the writer show that a large number of dairymen in North Carolina feed cotton-seed hulls, either alone or in combination with other coarse feeds, as roughage for dairy cows. Indeed it was found that hulls were fed more largely than any other kind of roughage. More than one and one-half times as much hulls as corn stover are being fed.

Why farmers will continue to pay high prices for hulls rather than feed stover can be explained only on the supposition that they do not fully realize the feeding value of stover. This belief is strengthened by the fact that many of them do not even attempt to harvest corn stalks, but allow them to go to waste in their fields.

OBJECT AND PLAN OF EXPERIMENT.

In view of the facts presented above, it was thought desirable to demonstrate the feeding value of corn stover by feeding it in comparison with cotton-seed hulls, one of the most commonly fed roughages.

For this experiment seven grade cows, from two to three months in lactation, were fed during three periods. The roughage consisted of shredded corn stover in the first and third periods, and of cotton-seed hulls in the second period. Closing the test with the same roughage used at the beginning tends to balance up any changes in milk and butter-fat yield due to advanced stage of lactation and the unfavorable effects of continued feeding on dry roughage. The grain ration was the same throughout the test. It consisted of a mixture of 4 pounds of cotton-seed meal, 2 pounds of dried brewers' grains, and 1 pound of linseed meal. All cows received 8 pounds of the grain mixture per day except Nos. 6 and 7, which received 10 pounds. The amount of roughage which the cows received was the same throughout the test, being 14 pounds per individual, with the exception of cows Nos. 1 and 4, each of which received 16 pounds per day.

Each period lasted twenty-two days exclusive of thirteen days preliminary feeding for Periods II and III and twenty days preliminary feeding for Period I. The longer preliminary feeding for Period I was thought desirable because the cows did not take very kindly to an all-dry feed after having been on a ration of equal

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parts of stover and silage for more than two months prior to the experiment.

The milk from each cow was weighed daily, and weekly determinations were made on composite samples of the milk by the Babcock test. All cows were weighed once a week.

The hulls were mixed with the concentrates before feeding. The stover, on the other hand, was always fed after the concentrates.

The corn from which the stover was made was thoroughly matured before cutting and allowed to stand in small shocks in the field from six to eight weeks, during which time it had received several drenching rains. There was practically no green color left in the stover at the time of shredding; neither were there any corn grains or nubbins found in it. On the whole, the stover was of a rather inferior quality. The following analyses, supplied by the Chemical Division, gives an idea of the grade of the different feeds used in this and the following experiments:

TABLE I.—PERCENTAGE COMPOSITION OF FEEDS.

Feed.	Moisture.	Protein.	Fat.	Nitrogen-Free Extract.	Crude Fiber.	Ash.
Cottonseed Hulls	10.76	5.72	1.04	29.07	51.17	2.24
Cottonseed Meal	6.87	38.93	10.53	28.06	8.79	6.80
Linseed Meal	8.03	34.87	8.81	34.18	8.83	5.28
Dried Brewers Grain	7.92	22.56	5.76	42.14	18.33	3.29
Corn Stover	7.83	4 04	1.31	47.29	35.18	4.35

MILK AND BUTTERFAT PRODUCTION.

The milk and butterfat yielded by each cow during the test are shown in the following table:

TABLE II.—SHOWING MILK AND BUTTERFAT YIELDS, AND LIVE WEIGHT.

No. Cow.	Period.	Milk—Pounds.	Fat—Per cent.	Butterfat—Pounds.	Average Weight of Cows—Pounds
1	I. Stover	335.2	5.0	16.76	660
	II. Hulls	332.8	5.4	17.97	656
	III. Stover	316.7	5.4	17.10	639
2	I. Stover	400.2	4.1	16.40	687
	II. Hulls	342.	4.2	14.36	687
	III. Stover	316.6	4.2	13.30	672
3	I. Stover	405.4	4.4	17.88	587
	II. Hulls	353.4	4.9	17.31	571
	III. Stover	340.3	4.8	16.33	569

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TABLE II.—Continued.

No. Cows.	Period.	Milk—Pounds.	Fat—Per cent.	Butterfat—Pounds.	Average Weight of Cows—Pounds.
	I. Stover	484.4	4.5	19.55	824
4	II. Hulls	375.	4.7	17.62	794
	III. Stover	331.	4.6	15.23	767
	I. Stover	468.7	4.5	21.19	805
5	II. Hulls	409.8	4.5	18.44	785
	III. Stover	363.4	4.5	15.35	806
	I. Stover	359.7	4.4	15.82	784
6	II. Hulls	278.5	4.8	13.36	769
	III. Stover	262.4	4.7	12.33	778
	I. Stover	335.6	5.2	17.45	688
7	II. Hulls	322.9	5.4	17.43	657
	III. Stover	284.3	5.7	16.77	658

From the results contained in Table II it will be seen that all cows fell off in milk yield during the Hull period and again during the Stover period following, the amount varying with different individuals. It is noteworthy also that in the case of cows Nos. 3, 4 and 6 the percentage of fat present in the milk was a trifle higher in the Hull period than in the Stover period. This may possibly be due to the rather large shrinkage in milk in these instances.

The total yield of milk and butter-fat for each period is shown in the table below:

TABLE III.—Showing Total Yield of Milk and Butterfat and Total Live Weight.

Periods.	Milk—Pounds.	Butterfat—Pounds.	Live Weight—Pounds.
I. Stover	2789.2	125.0	5060
II. Hulls	2414.4	116.5	4919
III. Stover	2224.7	107.4	4889

Averaging the results of the two stover periods in Table III we find that the cows yielded 2482.0 pounds of milk during the Stover period against 2414.4 pounds for the Hull period. Similarly the cows during the Stover period yielded 116.2 pounds of butter-fat as against 116.5 pounds for the average of the Hull periods, showing in this experiment that cotton-seed hulls and corn stover had practically equal value as milk and butter-fat producers.

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Table II shows that the average weight of the individual cows was less during the Hull period than during the first Stover period, excepting cow No. 2, whose weight remained the same. Going from the Hull period to the last Stover period we find that four of the cows lost in weight, two gained and one remained practically unchanged.

Taking the weights of the cows collectively, we find that they averaged 111 pounds less in the Hull period than in the first Stover period, and 30 pounds less in the last Stover period than in the Hull period.

On the whole it may be concluded that the cotton-seed hulls and corn stover used in the experiment had about equal value in maintaining the live weight of the cows.

HULLS AND STOVER REFUSED.

The roughage refused at each feed was weighed and recorded separately for each cow. It was found that the amount of stover refused averaged from 3 to 4 pounds per cow, with the exception of cow No. 3 (the lightest in weight), which refused from 4 1-2 to 5 pounds daily.

At the beginning of the Hull period an attempt was made to feed the hulls and concentrates separately. This proved a failure, since most of the cows refused the hulls, and only a few ate as much as one-half the allowance supplied them. After the second day, therefore, the hulls were always mixed with the concentrates before feeding. Even when fed in this manner some of the cows showed a strong dislike for the hulls the first week, after which practically the entire amount supplied was consumed except in the case of cows Nos. 6 and 7, each of which would occasionally refuse from 1 to 3 pounds per day.

CORN STOVER.

For years corn stover has formed an important part of the roughage fed to cattle in the live stock sections of this country. This feed is especially suited for feeding in cotton growing sections where the majority of farmers have insufficient stock to warrant the erection of silos; and even where farmers have silos there will always be more or less stover to feed because of the large amount of corn which is planted solely for the grain it yields, leaving the stover as a by-product. But because it is a by-product it is not necessarily to be inferred that it is worthless; yet so it is undoubtedly considered by many, as evidenced from the thousands of acres of cornstalks which are allowed to go to waste in the fields every fall.

An important consideration in making stover is to have it palatable. The corn should therefore be cut as soon as sufficiently ma-

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tured, and be placed in shocks containing from one hundred to two hundred stalks. During fair weather the corn may be husked, as a rule, from two to three weeks after it is cut. When husked by a machine the stover is shredded at the same time, and placed under shelter. When husked by hand the stover should be sheltered with the same care and promptness. Long exposure of the stover in the fields greatly diminishes its nutritive qualities as well as its palatability. The damage to stover is especially great when drenched by heavy rains.

It is usually best to cut the stover in small pieces, say from one to three inches long, before feeding. Less is wasted by cattle in this way than when fed uncut or unshredded. There are thousands of stockmen, however, who are at present feeding uncut stover, and our own experience along this line convinces us that dairymen would save considerable money by feeding even the uncut stover, rather than purchasing cotton-seed hulls.

While much has been said in favor of feeding corn stover, it should be distinctly understood that the greatest feeding value of the corn plant is obtained when placed in the silo.

COTTONSEED HULLS.

Aside from their low nutritive value cotton-seed hulls do not seem very well suited for dairy cows, on account of their low palatability and digestibility. With the cows used in these experiments it was found that a majority refused the hulls when they were offered them unmixed with concentrated feeds. When mixed with the concentrates the cows would eat them, largely because they were obliged to do so in order to get the concentrates. On general principles it can not be considered good feeding to thus force cows to swallow a lot of unpalatable material, especially when such material has such a low digestibility. Digestion experiments show that only 41 per cent of the total dry matter in hulls is digestible as against 60 per cent for corn stover. Our experiments were of too short duration to show any appreciable digestive disturbances from the feeding of such undigestible material as cotton-seed hulls, but it can not be denied that continuous feeding of any undigestible feed must ultimately prove deleterious to the usefulness of a dairy cow.

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CORN MEAL VERSUS A MIXTURE OF CORN MEAL AND DRIED BREWERS' GRAINS AS A SUPPLEMENT TO COTTONSEED MEAL FOR MILK PRODUCTION.

OBJECT OF EXPERIMENT.

A problem that confronts many farmers is to find a cheap and satisfactory grain supplement to cotton-seed meal for dairy cows. Owing to its high protein content, cotton-seed meal can not be satisfactorily used as the sole concentrate, except possibly where silage, made from well-eared corn, constitutes the roughage.

Hitherto wheat bran has been commonly fed in connection with cotton-seed meal and when the latter is not too high priced, this combination gives very satisfactory returns. But during the past year the price of wheat bran has been so high as to make its use as a cow feed almost prohibitive.

A careful study of prices of different feeds suggested the use of either corn meal or dried brewers' grains, or both, as a satisfactory supplement to cottonseed meal. Both of these feeds could be bought at a lower price than wheat bran, and both were believed to have a higher feeding value.

The dried brewers' grains are of a light, fluffy nature and are highly relished by cattle; yet, owing to their high protein content, the objection may be raised that they do not form a balanced ration with cottonseed meal.

From the standpoint of balancing the nutrients in a ration where much cottonseed meal is fed there appears to be no feed more ideal than corn meal. But owing to the heavy nature of both the corn and cottonseed meal a combination of the two would ordinarily be considered liable to give rise to digestive disturbances.

The above possible objection to corn meal and dried brewers' grains suggested that a combination of the two would probably give the most satisfactory results when used to supplement cottonseed meal, and that possibly corn meal alone could be advantageously used for this purpose if no digestive troubles should arise on account of the heavy character of this feed. Accordingly it was decided to test these points by feeding a mixture of corn meal, dried brewers' grains and cottonseed meal in comparison with a mixture of corn meal and cottonseed meal.

PLAN OF EXPERIMENT.

Six grade cows, from three to four weeks in lactation, were used for the experiment. The feeding was divided into three periods. During the first period the cows received cottonseed meal and corn meal in equal proportions. In the second period the cows received a mixture of 4 parts cottonseed meal, 2 parts corn meal and 2 parts

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dried brewers' grains. The feed in the third period was the same as that of the first. The daily allowance of grain per cow during the entire test amounted to 10 pounds for cows Nos. 4 and 5, and 9 pounds for cows Nos. 2, 3 and 6. The roughage supplied throughout the test consisted of 14 pounds of shredded corn stover per cow daily. The stover was the same as that used in the Stover and Hull Experiment.

Each period lasted twenty-one days, and only Period I was preceded by seven days preliminary feeding. Closing the experiment with the same ration used at the beginning tended to balance up any changes in milk and butter-fat yield which might be attributable to the advancing stage of lactation, to loss of continuous feeding of unpalatable roughage, to change in weather and other environmental factors.

The grain was always fed before the roughage. The milk from each cow was weighed daily, and weekly samples of the milk were tested by the Babcock test. All cows were weighed regularly once a week.

The results obtained with the individual cows during the different periods of the test are presented in the following tables:

TABLE V.—Showing Milk and Butterfat Yields and Live Weight.

No. Cow.	Period.	Milk—Pounds.	Fat—Per cent.	Butterfat—Pounds.	Average Weight Cows—Pounds.
	I	528.1	4.36	23.03	721
1	II	511.6	4.20	21.49	717
	III	498.4	4.10	20.23	719
	I	527.1	4.13	21.77	603
2	II	459.0	4.30	19.74	606
	III	412.0	4.16	17.14	612
	I	455.5	4.36	19.86	787
3	II	410.8	4.48	18.30	767
	III	390.9	4.26	16.65	784
	I	542.7	4.40	23.85	724
4	II	486.4	4.45	21.64	738
	III	461.3	4.30	19.84	740
	I	612.8	4.00	24.51	795
5	II	528.8	3.90	20.62	786
	III	494.0	3.93	19.41	796
	I	520.2	.83	19.92	876
6	II	462.9	3.80	17.59	854
	III	428.2	3.73	15.97	847

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Summarizing the results contained in Table V we find the following:

TABLE VI.—Showing Total Yield of Milk and Butterfat and Total Live Weight.

Period.	Ration.	Milk—Pounds.	Butterfat—Pounds.	Live Weight—Pounds.
I	Corn + Cottonseed Meal	3186.4	132.97	4506
II	Corn + Dried Brewers' Grains + Cottonseed Meal	2859.5	119.38	4468
III	Corn + Cottonseed Meal	2679.8	109.24	4498
Average of Periods I and III		2933.1	121.10	4502

An inspection of the results in the two preceding tables shows there was a gradual falling off in the milk and butter-fat yield of the cows, individually as well as collectively, from the beginning to the end of the test. The decrease was so uniform that it could not, therefore, be attributed to a change in the grain ration, but must be laid to the unpalatable roughage fed. Table VI shows that the average milk and butter-fat yield of Periods I and III, in which corn meal and cotton-seed meal were fed, was slightly larger than that of Period II, in which dried brewers' grains replaced pound for pound one-half of the corn meal fed in Periods I and III.

Although no digestive disturbances resulted from the feeding of the combination of corn meal and cottonseed meal, yet the trial was too short to warrant a statement as to what the effects of such a mixure of heavy feeds might be, if fed continuously for a longer time.

Pending further investigation along this line, therefore, we are inclined to recommend to dairymen who are feeding much stover a grain ration consisting approximately of one-half cottonseed meal. one-quarter corn meal and one-quarter dried brewers' grains, or wheat bran, or some similar light, fluffy concentrate, depending upon the market prices of these feeds.

ROLLED OATS AS A SUBSTITUTE FOR MILK IN CALF FEEDING.

One of the essentials in building up a productive dairy herd is to raise the heifer calves from the best milkers. This is also the surest way to keep a herd free from disease. Moreover, where skimmed milk is available for feeding, the practice of raising the best calves is also the cheapest means of increasing and improving the dairy herd.

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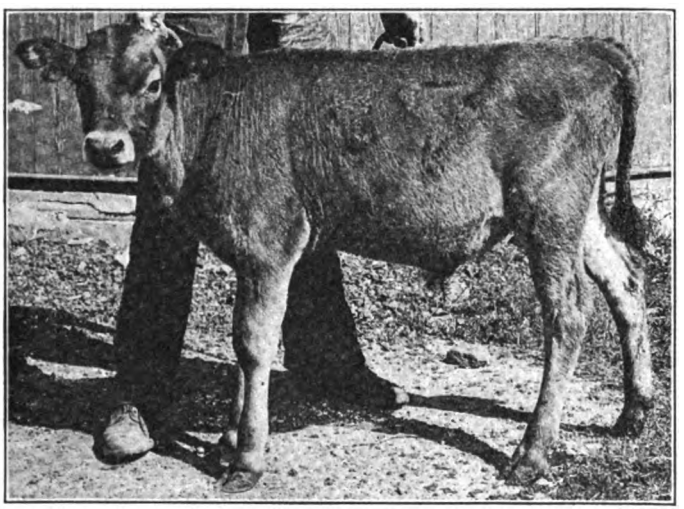
Hundreds of dairymen, however, who are supplying milk to towns and cities either have no skimmed milk at all or an insufficient quantity for calf rearing. Hence they prefer killing the calves to feeding them high-priced milk. In order to induce this class of dairymen to raise their calves, it became clear to us that some cheap and satisfactory substitute had to be found that would take the place of high-priced milk for feeding.



Grade Calf Reared on Rolled Oats.

In our efforts to find such a substitute, we were guided by the following requirements: that a feed that could take the place of milk for young calves must be very palatable and digestible, rich in muscle and bone-forming materials, and practically free from crude fibre. Cooked rolled oats suggested themselves as meeting all these requirements with the exception, perhaps, that there might be a possible deficiency in ash or bone-forming material. This feed was therefore given a careful test.

It was estimated in the beginning, from the composition of the feeds, that one pound of rolled oats was approximately equal in feeding value to one gallon of whole milk, and our feeding trials were conducted upon this basis. The rolled oats were prepared by adding boiling water to them at the rate of one gallon of water to twelve ounces of rolled oats, and the mixture was then allowed to stand until cool enough to feed.

The feeding of a number of calves was simplified by preparing the rolled oats for all in a can of suitable size, from which the proportionate amount for each calf was measured out with a dipper.

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All the calves used in the experiment, with one exception, were grade Jerseys, light to medium in weight. The daily allowance per calf during the thirteen weeks of the experiment was as follows:

First week—10 pounds whole milk.
Second week—8 pounds whole milk, 4 ounces rolled oats.
Third week—6 pounds whole milk, 8 ounces rolled oats.
Fourth week—4 pounds whole milk, 12 ounces rolled oats.
Fifth week—2 pounds whole milk, 12 ounces rolled oats, 0.2 pound grain mixture.
Sixth week—2 pounds whole milk, 12 ounces rolled oats, 0.4 pound grain mixture.
Seventh week—2 pounds whole milk, 12 ounces rolled oats, 0.6 pound grain mixture.
Eighth week—2 pounds whole milk, 12 ounces rolled oats, 0.8 pound grain mixture.
Ninth week—2 pounds whole milk, 12 ounces rolled oats, 1.0 pound grain mixture.
Tenth week—12 ounces rolled oats, 1.0 pound grain mixture.
Eleventh week—12 ounces rolled oats, 1.0 pound grain mixture.
Twelfth week—12 ounces rolled oats, 1.2 pounds grain mixture.
Thirteenth week—12 ounces rolled oats, 1.2 pounds grain mixture.

The grain mixture consisted of one part each of corn meal, linseed meal and wheat bran.

The milk was always added to the oat preparation just previous to feeding.

In addition to the above feeds, the calves received all the hay they would eat during the winter, while in spring they received one feed of hay with pasturage additional.

On the basis that one pound of rolled oats is equal to one gallon of whole milk, and that whole milk is worth 8 cents per quart to milkmen, the cost of the milk for a thirteen-weeks-old calf receiving no rolled oats is $26.96. When rolled oats (which cost 4.4 cents per pound delivered in barrel lots) are substituted for milk as shown above, the cost of the calf feed for the same period is only $12.46, a saving of $14.50 in favor of the rolled oats.

The weekly weights of the calves fed rolled oats and those of two calves fed skimmed milk as a check on the work are presented in the following table:

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TABLE VII.—Showing Weekly Gains of Calves Fed Rolled Oats and Skimmed Milk.

Age of Calf.	Weekly Weight of Calves—Pounds.										
	Rolled Oats.									Skimmed Milk.	
	Calf No. 1.	Calf No. 2.	Calf No. 3.	Calf No. 4.	Calf No. 5.	Calf No. 6.	Calf No. 7	Calf No. 8.	Calf No. 9.	Calf No. 10	Calf No. 11
At birth	63	83	62	60	62	60	66	50	49	60	46
One week	69	94	70	65	70	------	------	------	------	68	52
Two weeks	78	101	77	70	73	------	------	------	------	74	62
Three weeks	84	106	85	74	74	------	------	------	67	82	67
Four weeks	88	115	88	81	81	------	------	------	------	87	74
Five weeks	94	128	98	86	86	100	------	76	------	97	82
Six weeks	99	131	102	88	90	104	------	------	------	106	90
Seven weeks	108	140	111	91	98	108	------	------	------	115	96
Eight weeks	118	147	120	101	107	114	------	------	------	122	100
Nine weeks	125	159	129	112	115	123	------	------	------	135	113
Ten weeks	139	167	140	122	124	129	------	------	------	146	125
Eleven weeks	151	171	151	134	137	139	144	------	------	159	130
Twelve weeks	170	178	159	141	145	153	154	------	------	170	137
Thirteen weeks	180	188	169	155	155	166	163	168	159	180	146
Average daily gain	1.28	1.16	1.18	1.00	1.00	1.16	1.09	1.30	1.12	1.32	1.10

Skimmed-milk calf No. 10 received the following daily ration:
First week—10 pounds whole milk.
Second week 7 pounds whole milk and 4 pounds skimmed milk.
Third week—4 pounds whole milk and 8 pounds skimmed milk.
Fourth week—2 pounds whole milk, 10 pounds skimmed milk.
Fifth to fourteenth week—14 pounds skimmed milk.

Calf No. 11 received only 8 pounds of whole milk the first week, and subsequently was fed the same allowance of whole milk as calf No. 10, but received 2 pounds less of skimmed milk per day. The grain and roughage for the two skimmed-milk calves were the same as those for calves fed on rolled oats.

Table VII shows that the calves fed on rolled oats made practically the same gains as those fed skimmed milk.

Considering that all calves but No. 2, which was a grade Holstein, were light-weight, common-grade Jersey calves, and that the allowance of whole milk and the rolled oats equivalent were less than is usually fed, the gains here reported are considered as fairly satisfactory. The calves showed good bone and muscle development.

We strongly recommend the feeding of cooked rolled oats to calves for all who either have no skimmed milk or an insufficient

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quantity for calf-rearing; and we confidently expect that a trial by such dairymen will result in the rearing of every calf that promises to become a valuable animal in the dairy.

One thing that especially commended itself in the rolled oats feeding was the evident relish with which the calves devoured them. The extra labor entailed in the feeding of the rolled oats was insignificant as compared with the saving effected.

One precaution to observe in feeding rolled oats to calves is not to use it in too large quantities, owing to the laxative character of this feed. Indeed, our experience indicates that it is best not to feed more than 12 ounces daily to each calf. It is important also that the rolled oats and milk be supplied as near the temperature of blood heat as possible.

In these trials the grain was always supplied first and the roughage later, the milk and oats being fed immediately after the grain. The latter was fed from a sterile tin bucket, which was also used for feeding the milk and rolled-oat mixture.

The calves were removed from the cows when twenty-four hours old, and received regularly two feeds daily, except during the first few days, when they were fed three times per day.

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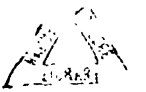

THE NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION 1908-1909

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THIRTY-SECOND ANNUAL REPORT

OF THE

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

FOR THE

YEAR ENDING JUNE 30, 1909

INCLUDING SCIENTIFIC PAPERS AND BULLETINS,
Nos. 200, 201, 202, 203, 204

WEST RALEIGH, N. C.

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UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

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W. A. WITHERS.....Chemist
F. L. STEVENS.....Vegetable Pathologist and Bacteriologist
J. S. JEFFREY.....Poultryman
F. C. REIMER.....Horticulturist
R. S. CURTIS.....Animal Husbandman
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P. L. GAINEY.....Assistant Bacteriologist
L. R. DETJEN.....Assistant Horticulturist
F. W. SHERWOOD.....Assistant Chemist
A. F. BOWEN.....Bursar
C. P. FRANKLIN.....Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

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North Carolina Agricultural Experiment Station,
Office of the Director.
West Raleigh, N. C., June 30, 1909.

To His Excellency, William W. Kitchin,
Governor of North Carolina.

Sir:—I have the honor to submit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts for the year ending June 30, 1909.

Trusting that this report will prove satisfactory to your Excellency, I am, Yours very truly,

C. B. Williams,
Director.

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THIRTY-SECOND ANNUAL REPORT

OF THE DIRECTOR OF THE

N. C. AGRICULTURAL EXPERIMENT STATION

FOR THE YEAR ENDING JUNE 30, 1909.

BY THE DIRECTOR.

Generally, the work of the Station in all its branches has been increased and actively carried forward by the various workers in a fairly satisfactory manner. Below is given, briefly, something as to the nature and scope of the work which is being conducted by the several Divisions of the Station. This summary is made up from the reports of the different workers and from the observations of the Director.

DIVISION OF AGRONOMY.

The experimental work of this Division has progressed actively along the same general lines as previously reported. Considerable effort has been exerted in the determination of best fertilizer combinations and the most economical quantities of fertilizers to use per acre, especially for cotton and corn. These experiments have shown unmistakably that phosphoric acid is the chief deficiency of our soils here and that potash is the one less needed for maximum yields. The field results have been confirmed by chemical analyses of the soil. The fertilizer formulas used largely by the farmers in the Piedmont section of the State for cotton are not the ones which, judging from our results, afford the greatest profit per acre. The phosphoric acid in them should, as a general thing, be increased, while the potash might be decreased.

The variety tests this year embrace a study of 68 varieties of corn; 42 of cotton; 23 of soy, adsuki and seta beans; 30 of cowpeas; 15 of wheat; 49 of oats, and 4 of clover. In addition to this comparison of varieties with reference to yield, an intimate study is, at the same time, being made of the characters of each variety, with the hope of determining those which are correlated in the different varieties with high yield and superior worth. Variety-distance tests with 68 varieties of corn and 3 of cotton, each of widely different characters, are being conducted to ascertain what distancing of the different varieties produces the best results. From the field seed-selection experiments with corn, cotton, wheat and oats, recently

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started, much is expected in the way of improvement and practical scientific information. In the variety test of oats an effort is being made to determine those varieties which are best adapted for fall and spring sowing. Marked differences have developed, not only in yield, but also in earliness and consequent adaptation for different soils and localities and for specific purposes. For sowing in combination with crimson clover or Canada field peas, the earliness in maturity of Burt, Kherson and Culberson varieties especially fits them for this purpose, as they reach the haying stage at practically the same period as do the clover and peas. The white-blooming crimson clover may be used in mixtures with later maturing varieties, such as Red Rust-proof or Appler, as it blooms ten to fourteen days later than the regular crimson clover.

Investigations are being carried on with 68 varieties of corn to determine the factors which operate in the production of suckers on the corn plant and to ascertain the relation which their undisturbed development bears to yield of grain and stover. As these investigations advance, many interesting and economic features present themselves which will shed much light upon the nature of the characters of corn varieties when grown under widely varying conditions of fertilization, distancing and season.

Top-dressing experiments with nitrate of soda and sulphate of ammonia on oats and wheat are being conducted to determine their actual and relative values for this purpose. A comparative study is also being made of different carriers of phosphoric acid and nitrogen for fertilization of cotton and corn.

Many combinations of legumes are being grown to ascertain their relative value for hay and pasturage.

A systematic effort is being made to determine the effects upon percentage of lint to seed, and length and tensile strength of the staple of cotton by allowing the seed cotton to stand exposed for a year to the average conditions prevailing on the farm. This Division is especially fortunate in having under its control considerable land which may be used in making direct application, on a considerable scale, of the facts which are evolved from the carefully planned experiments which are being conducted along different lines. By this means it is felt that a broader conception of agronomical problems in general and their practical solution is obtained.

DIVISION OF CHEMISTRY.

During the year the Chemical Division has sustained intimate cooperative relations with the Biological Division in soil nitrification and ammonification studies and with the Animal Husbandry and Veterinary Divisions in cotton-seed meal toxicity investigations. The preparation of the twenty-two fractions used in the cotton-seed meal feeding experiments with hogs and guinea pigs has largely been per-

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formed by the workers of this Division. Much work has been done in connection with these investigations in making chemical determinations of the composition of various feeds, fractions of cotton-seed meal employed in the experiments and of the urine secreted by animals fed on each of these. The Division has been materially strengthened by the addition of an assistant, and, during the first ten months of the year, 3,825 determinations on 1,414 samples have been made. In the bacteriological soil survey of the State which is being carried on this summer co-operatively by this and the Biological Division, the examinations of the Bacteriologist for nitrifying and ammonifying efficiency, nitrifying and ammonifying inoculating power, nitrifying capacity, and bacterial count are being supplemented in each case by a careful chemical determination of the amount of nitrates, nitrites, and ammonia present.

DIVISION OF BIOLOGY.

During the year the research work has been carried forward largely along lines previously begun and reported on. In co-operation with the National Bureau of Plant Industry, this Division in continuation of its Plant Disease Survey of the State has conducted much correspondence with farmers and public-school teachers in order to determine definitely how widespread certain plant diseases are in different localities and to ascertain the amount of damage to crops and fruits they produce. New diseases of the apple, lettuce, clover, tuberose, fig, carnation, privet, peanut and vetch occurring in the State have been studied and the fungus causing each has been isolated, identified, and described.

The experiments which are being conducted at Auburn on soil badly infected with watermelon wilt will be continued in an effort to secure strains of melons which possess desirable eating and shipping qualities and which may be successfully grown upon soils affected with this disease. The importance of this work cannot be too strongly emphasized, as the melon industry is an important one and in many localities is beginning to be menaced by the appearance and rapid spread of this disease. Melons cannot, to a profitable extent, be grown at present on a badly infected field, and unless wilt-resistant varieties or strains are bred or found, the industry will be wiped out in certain important infected areas of rapidly increasing size.

The tobacco-wilt experiments are this year continued at Creedmoor, which is located in the light tobacco belt of Granville County. Eleven strains of tobacco are being used in the work, and they were put out on badly infected soil. Although there did not develop any marked difference between the ability of the Sumatra, Turkish and Italian types to withstand the wilt, yet the finer qualities of the Sumatras has led to the crossing and use of two strains of this type with the native bright tobacco of the infected section with the hope of securing

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wilt-resistant strains of as nearly the same quality as possible as the native bright tobacco. It is planned to devote during the present season about one-fourth of the space allotted to this experiment to a field-study of the resistance and quality of these crosses made last year.

In the lettuce-drop investigations efforts have been directed principally along the line of preventing the formation of sclerotia by the fungus causing this trouble, as it seems to be the only means this disease has of being carried over winter. Should any of the methods devised prove effective against the formation of sclerotia, then the eradication of the disease from infected lettuce-beds seems assured.

The soil bacteriology investigations which this Division is carrying on in co-operation with the Chemical Division have been greatly strengthened by further work and extension. Results secured have brought out rather conclusively the importance of conducting tests to determine the ammonifying and nitrifying powers of soils on the soils themselves, rather than by the use of culture solutions in the usual way, as there seems to be no definite relation whatever between the results on nitrification and ammonification secured on the soil itself and the solution. Methods have been devised for determining fairly accurately the nitrifying and ammonifying power of soils, using the soil as a medium. In marked contrast to the commonly accepted notion that all soils are well supplied with nitrifying organisms, it has been found that 71 per cent of the local soils which have undergone examination have shown very low nitrifying power. The facts have led to the inauguration of a new line of experiments which are designed to study the relative acceptability to plants of nitrate-nitrogen and ammoniacal nitrogen. The experiments are being conducted under complete bacteriological and chemical control. To supplement these, a systematic bacteriological survey of the different soil types of the State has been started, and on each soil determinations of its nitrifying and ammonifying power will be made. Contrary to the accepted idea, results thus far secured seem to indicate very strongly that the presence of organic matter in the soil does not always exert an inhibiting influence upon the activity of nitrifying organisms.

The ptomaine studies which were started last year have been temporarily suspended, due to the absence of suitable material and because of pressure of other investigational work.

DIVISION OF POULTRY.

The operations of the Poultry Division have been to a large extent carried on in the direction of testing various systems of feeding young chicks, managing incubators and brooders and comparing different feeds and combinations for the production of eggs and meat. From the results secured in the cotton-seed meal feeding experiments it

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was demonstrated that this material may be fed without detriment to the health of the poultry to the extent of one-fourth of a ration consisting of cotton-seed meal and corn, when the stock is allowed range on grass or other green crops. It will be noticed from results of subsequent experiments that, although the ration containing cotton-seed meal costs less than the ones containing meat and bone meal, yet the latter ones, by inducing earlier development and laying, have produced the cheapest gains in weight and egg production. During the summer it is planned to study the value of skim-milk as a substitute for meat meal and cotton-seed meal.

In the pedigreed breeding experiments for egg production, work has been continued along the same general lines as previously reported. Some of the Barred Plymouth Rock hens used in this work have made a good showing, as also have their pullets. Last year Barred Plymouth pullet No. 7113 laid 143 eggs in seven months. Several daughters of this hen are being used this year in furtherance of the work and studies. The inbreeding work started last year is being continued, but results will not be expected before next season.

In the incubator experiments an effort is being made to determine if it is advisable to artificially supply moisture to and use disinfectants in the incubators before each hatch comes off. In these comparative studies, eggs from the same hens are being used in order to eliminate as far as possible the effects of differences in individuality. Experiments with the fireless brooder have demonstrated that they may be operated successfully, but that the chief drawback to their use is the greater amount of attention which the chicks confined in them require for the first few days.

DIVISION OF HORTICULTURE.

The attention of the Horticulturist has been confined chiefly to preparation for and in a study of "double flower" and self-sterility of blackberries and dewberries with the purpose of determining the nature and cause of these abnormalities. The work was started last year and is now fairly well under way. As 23 varieties of blackberries and 14 varieties of dewberries are embraced in these investigations, it is planned also to make careful observations as to the relative standing of these in reference to earliness and amount and character of fruit. A study will be made at the same time of the influence of many fertilizer carriers and combinations upon yield, "double flower" and self-sterility of the various varieties under experimentation. The careful microscopic study of the doubled flowers and accompanying rosette growth of stems and leaves of the Wilson blackberry and of the character of the flower-parts of the notably self-sterile Premo dewberry, which is being conducted in the laboratory simultaneously with the field work, will doubtless reveal much as to the nature and cause of "double flower" and self-sterility.

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Field experiments were begun this spring with eight varieties of dewberries to determine the ability of the several varieties to set fruit without cross-pollination. These were undertaken by enclosing 500 flower clusters in paper bags before the flowers opened. Results thus far secured by the Horticulturist seem to indicate that "double flower" is intimately associated in some way with early dropping of the old leaves during the previous year and to the premature development of buds which would normally produce fruit the succeeding year.

Some preliminary work with figs, Japanese plums, and muscadine grapes has been gotten well under way during the year. A bulletin on the Origin and Importance of the Scuppernong and Other Muscadine Grapes is now in press. This will be followed by study and publication on other features of muscadine grape growing. It is a notable fact that most of the leading varieties of muscadine grapes have been originated in this State.

DIVISION OF ANIMAL HUSBANDRY.

The Animal Husbandman has devoted considerable effort and time in providing new equipment and in getting under way new lines of experimentation. A major portion of his efforts has, however, been given to a careful supervision of the investigations which are being conducted jointly by the Animal Husbandry, Veterinary and Chemical Divisions to determine the cause for the disastrous results which frequently follow the feeding of cotton-seed meal to swine, and to isolate, if possible, the toxic principle, if such it may be. Feeding experiments which have been carried on by other experimenters with cotton-seed meal up to the present have been of an empirical nature, and have afforded information only with reference to the quantity which may be fed, length of the feeding period and the symptoms and post-mortem revelations produced by overfeeding. During the year 28 pigs and 93 guinea pigs have been used in carrying on these investigations. Out of the 23 fractions of cotton-seed meal that have been fed, 7, having proven practically innocuous, have passed from under further experimentation for the present. For comparison with the results secured with feeding cotton-seed meal, linseed meal and blood meal, as highly concentrated proteinaceous feeds, are being fed with the same supplementary feeds and in the same proportions to guinea pigs under control conditions. A series of experiments has recently been started to determine the toxicity of cotton-seed meal when fed in conjunction with corn and green clover leaves to guinea pigs. From the results secured in feeding cotton-seed meal to horses and mules, it is felt that as a supplement to ear corn, shelled corn and corn-and-cob meal, this feed cannot generally be fed in larger quantities than three-quarters to one pound per day and have it eaten clean. When fed in connection with dried brewers' grains or wheat

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bran one and one-half pounds were readily eaten. During the course of the experiments it has been observed that horses eat the meal more readily than do the mules.

Experiments are being conducted to determine the value of green crops in general as pasturage for hogs and to further ascertain the relative value of oats, rye, and rape, sown alone and in different combinations. In these experiments cowpeas, peanuts, and sweet potatoes have been used, allowing the hogs to run on them *ad libitum* after the crops have reached almost maturity. By a system of rotation it has been possible to have green crops practically the entire year for the hogs to run on. The results thus far secured from this succession of crops have been quite encouraging. Grading experiments have been started and are well under way with hogs. For this work a pure-blooded Berkshire sire is being used.

During the year a Bulletin on Feeding Fermented Cotton-seed Meal to Hogs has been prepared and issued, and two others are in course of preparation.

Plans are being developed for this Division to feed experimentally this fall a carload of high-grade mountain steers.

DIVISION OF DAIRY HUSBANDRY.

The Dairy Husbandman has, during the year, given much time to working out the details of a commercial method of preparing cottage cheese. A feeding experiment with eight dairy cows has been conducted to determine the relative economy of feeding medium and narrow nutritive rations for milk and cream production under North Carolina conditions. The results of this experiment and of cottage cheese work are now in Bulletin form ready for publication. During the year Bulletins on Handling and Marketing of Milk and Cream and Feeding Experiments with Cows and Calves have been prepared and published.

DIVISION OF ENTOMOLOGY.

Much time of this Division has been devoted to studies of the life-history and habits of the cabbage webworm, harlequin cabbage bug and plum curculio, and during the year two Press Bulletins giving directions for combating the harlequin bug have been prepared by the Entomologist and issued.

The fumigation experiments which have been carried on have demonstrated rather strikingly the unreliability of carbon bisulphide as a remedy against corn weevils in the average corn bin, especially when used in the quantities generally recommended per thousand cubic feet. Otherwise following the commonly given directions in using this agent, but employing twenty times the quantity generally recommended, it was found that it was not effective when used even in

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this quantity in the Station barn as a destroyer of weevils. Sulphur fumes were tried and were found satisfactory so far as killing the weevil was concerned, but cannot be recommended for general use, as the fumes materially reduce the germinating power of corn thus treated. The plum and apple trees at the Poultry farm which became badly infested with San José scale have almost been freed from it by systematic spraying. The apple trees belonging to the Station have also been kept quite free from the ravages of codling moth by two sprayings, just before the trees bloom, with Bordeaux mixture containing three pounds of arsenate of lead to fifty gallons of the mixture.

An insect collection, representing all the beneficial and injurious forms occurring in the State, with records of dates and places of occurrence, is gradually being brought together.

DIVISION OF VETERINARY SCIENCE.

The time of this new Division has largely been taken up in aiding in carrying forward the cotton-seed meal feeding investigations which the Division is conducting jointly with the Animal Husbandry and Chemical Divisions. The Veterinarian has made daily observations and kept records of the weight, temperature, pulsation and respiration of a good many of the hogs and guinea pigs which are being employed to further the investigations. A study in many cases is being made of the blood which is diseased by prolonged cotton-seed meal feeding. All animals dying have been subjected to post-mortem examination and all revelations as to internal derangement were carefully noted. In many instances diseased tissues were preserved for subsequent microscopic examination and study.

In co-operation with the Biological Division, this Division has done some work along the line of inoculating milk with dirt and germs from different sources to determine if such milk after a sufficient lapse of time would produce ptomaine poisoning when injections of it were made into guinea pigs. Some work has been carried on during the year to determine the value of a recently discovered serum as an effective preventive against hog cholera and to determine the relative worth of turpentine and thymol as vermifugal agents for hogs infested with worms.

POLICY OF THE STATION.

It would appear that the Station can best subserve the purposes of its creation by confining its efforts as largely as possible to investigational work along a few lines which have been carefully planned, with a clear conception of the ends to be attained, by strong and specially

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equipped men of experience who are broad, painstaking, inventive, resourceful and are not afraid to work and who can distinguish between truth and opinion and between fact and theory. To a large extent, agricultural education, which is making such rapid progress in these latter days, is largely limited in its development by the advances made by the Experiment Stations in supplying material of a fundamental nature for teaching purposes. The Station, under the provisions of the Adams Act, has resources for carrying on research work of an original and fundamental nature in agriculture.

An effort is being made to have all work of an investigational nature so planned and conducted that the results secured will not only have scientific worth, but will also have direct economic value. Although it has no direct bearing on investigations under way, some attention has been devoted to an improvement in the appearance of the grounds, buildings and general surroundings, because it is felt that the manner in which the general operations of the Station are conducted will be a potent factor in determining the local standing and influence of the Station, if not more.

NEW BARN AND SILO.

During the year a new up-to-date gambrel-roof barn has been finished. It is 100 feet long and 42 feet wide and has haymow space for holding something like 150 tons of forage. It is ideally located, well lighted and ventilated and is provided with roomy granaries, with stalls and driveways and sliding doors at all openings. At the east end of the building a large end haymow door is arranged with flexible wire cable, pulleys and weights, and is made to slide in guides on the exterior of the building. Hay trackage and carrier run the full length of the barn.

At the west end of the barn a stave silo, of 130-ton capacity, is conveniently located both for filling and feeding from. The design and arrangements of the barn specially fit it for use in feeding beef cattle.

BULLETINS.

Bulletins have been issued during the year as follows:

No. 200—*Feeding Fermented Cotton-seed Meal to Hogs,* by R. S. Curtis.

No. 201—*Origin and Importance of the Scuppernong and Other Muscadine Grapes,* by F. C. Reimer.

No. 202—*Manufacture and Marketing of Cottage Cheese, Skim-milk-Buttermilk and Ice-cream,* by John Michels.

No. 203—*Corn Weevils and Other Grain Insects,* by R. I. Smith.

No. 204—*Some Factors Involved in Successful Corn Growing,* by C. B. Williams.

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No. 16 (Press Bulletin)—*Selecting Seed Corn for Larger Yields,* by C. B. Williams.

No. 18 (Press Bulletin)—*The Apple Bitter Rot,* by F. L. Stevens.

No. 19 (Press Bulletin)—*Suppression of Terrapin Bug,* by R. I. Smith.

No. 20 (Press Bulletin)—*Spring Destruction of Terrapin Bugs,* by R. I. Smith.

The reports of the heads of the several Divisions, financial statement, and scientific papers follow.

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REPORT OF CHEMIST.

During the year ended June 30, the Chemical Division has been engaged mainly in investigations relating to nitrogen metabolism in soil and the toxicity of cotton-seed meal.

The investigation relating to soil bacteriology has been conducted in co-operation with the Division of Bacteriology. The analytical portion of that work has involved 5,606 determinations in 1,579 samples of soil and 526 solutions, as follows:

Nitrogen as ammonia by magnesium oxide	1,030
Nitrogen as ammonia by sodium hydroxide	240
Nitrogen as nitrates colorimetrically	107
Nitrogen as nitrates Tiemann-Schulze	1,529
Nitrogen as nitrites Griess	1,446
Nitrogen as nitrites and nitrates, Diphenylamine	1,190
Nitrogen total by Kjeldahl	20
Nitrogen total by Kjeldahl and Nessler	44
	5,606

Three articles have been prepared representing the results of this work. The first was published in the report of the Station for 1908-09, and in the *Centralblatt fuer Bakt,* XXIII, 355-373. The second and third articles have been published by the same journal and are submitted for publication with this report. An article on the work was published in *Science,* March 26, 1909, and a report of article three was made to the North Carolina Academy of Science at its May meeting. A fuller account of the work is shown in the report of the Bacteriologist.

The investigation relating to the toxicity of cotton-seed meal has been conducted in co-operation with the Animal Husbandry and Veterinary Divisions. The analytical portion of this work has involved 60 determinations in 19 samples of cotton-seed meal, and 495 determinations in 129 samples of pig and guinea-pig urine, as follows:

Albumin	129
Nitrogen by Kjeldahl	13
Nitrogen by ureometer	95
Specific gravity	129
Sugar	129
	495

Ash	3
Betain	1
Choline	1
Crude fiber	2
Extract by carbon tetrachloride	2
Extract by ether	4
Extracts by six other solvents	8

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Moisture	5
Nitrogen	32
Pentosans	1
Raffinose	1
	60

The feeds for the guinea pigs have been prepared mainly by the Chemical Division and the work so far has been planned mainly by the Division. Fractions of the meal obtained by the use of various solvents have been fed to guinea pigs, and several of these feeds have been found to be nontoxic. The toxic portions are still being fractioned and fed.

The miscellaneous work of the Division has consisted of 72 determinations in 41 samples. The samples were as follows:

Boiler scale	1
Feeding stuffs	18
Fertilizing materials	8
Marls	6
Minerals	3
Soils	4
Urine	1
	41

The 72 determinations in the 41 miscellaneous samples were as follows:

Calcium oxide	9
Carbon dioxide	8
Gold	1
Moisture	4
Nitrogen as ammonia by magnesium oxide	1
Nitrogen as nitrites	1
Nitrogen as nitrates	1
Nitrogen total	13
Phosphorus pentoxide	9
Potassium oxide	4
Sulphur dioxide	13
Acidity	3
Ether extract	4
Humus	1
	72

The grand total of work for the year was 6,233 determinations in 2,294 samples.

During the past year the chief of the Division was elected vice president of the Association of Official Agricultural Chemists, and, in addition to the publications referred to, has published an article in the *Student Farmer, The Progressive Farmer,* and the *News and Observer* upon the importance of the substitution of horse power for human power in agriculture in North Carolina.

Dr. W. A. Syme was appointed State Oil Chemist, and has tendered his resignation, to take effect May 1. I am glad to bear witness to his ability, skill, high character and pleasant personality.

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J. K. Plummer was added to the staff of the Division on August 15, and has proven a very rapid and satisfactory worker. He will leave his work here on September 1 to accept a scholarship and pursue post-graduate work at Cornell University. F. W. Sherwood was added to the staff of the Division on May 1, and Hubert Hill has assisted with the work from time to time.

The Division needs more commodious quarters, which I trust will be provided in the new building.

I wish to express my appreciation of the faithful work by the assistants in the Division and to thank you for your cordial co-operation and interest.

Very respectfully,

W. A. WITHERS,
Chemist.

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REPORT OF BIOLOGIST.

I hereby submit a report of the Division under my charge for the fiscal year now closing.

The following completed articles represent experiments completed and conclusions reached by work of this Division:

Concerning Apple Diseases.

Hypochnose of Pomaceous Fruits.

Soil Bacteriology (in Co-operation with the Division of Chemistry).

II. Studies in Soil Bacteriology.

Ammonification in Soils and in Solutions.

Concerning the Existence of Non-nitrifying Soils.

Miscellaneous Plant Diseases.

A New Fig Anthrachnose, Colletotrichose.

Alternariose of the Carnation.

Variation of Fungi Due to Environment.

An examination was made of three samples of corn meal received from Wilmington, N. C., which were suspected of bearing a causal relation to pellagra, several cases of which had occurred in that vicinity recently, and a report was made concerning the more common species of fungi which were found therein.

One Press Bulletin, No. 18, *Apple Bitter Rot,* has been issued.

INCOMPLETE WORK.

In addition to the above work which may be regarded as completed, much other new work is under way.

Apple Diseases.—Several interesting apple diseases, some of them new, are still the subject of study.

Lettuce Experiments.—Work on lettuce sclerotiniose has been continued, following the suggestions indicated by our previous studies, which showed that hibernation of the fungus seems to be limited to the sclerotia. The lettuce bed was last year thoroughly infected with the disease. Our efforts this year have been entirely directed to the prevention of the formation of sclerotia, with the hope that within a year or two we may be able to demonstrate the possibility of completely eradicating the disease from an infected bed. Also an undescribed lettuce disease of very great destructiveness has been brought to our attention from Fayetteville and elsewhere. The bacteria causing this disease has been isolated. Artificial infection has been produced and we are now determining the identity of the organism, its relationship and its characters.

Sclerotinia on Clover.—A very serious clover disease caused by

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this fungus, close kin to that on the lettuce, has come to the laboratory. The causal fungus has been isolated and successful inoculations made.

Soil Bacteriology.—This work is being conducted jointly by the Biological and the Chemical Divisions. At present two main lines are under investigation, as follows:

1. Methods for the determination of Nitrification and Ammonification. This work embraces a trial of the efficiency of various methods to determine these factors.

2. Ammoniacal Nitrogen versus Nitrate Nitrogen. The fact that many of our soils are deficient in nitrifying power has raised the question whether nitrates are of great importance to plants or whether ammoniacal nitrogen may not be fully as acceptable to plants as nitrate nitrogen. To test this question, numerous experiments are under way under full chemical and bacteriological control.

BACTERIOLOGICAL SOIL SURVEY.

In order to ascertain whether the deficiency in nitrifying power, so marked in the neighborhood of Raleigh, is general throughout the State, it is planned to receive numerous samples of typical soils from all portions of the State and to determine their ammonifying and nitrifying powers, employing the methods devised by us and which are mentioned above.

In addition to the above major investigation, several other interesting observations have been made. For example, a serious outbreak of the *egg-plant wilt;* the occurrence of a very serious *maple-leaf disease* in Raleigh which seems to be due to a yeast; the occurrence of a *cotton-leaf* spot due to a species of *Phyllosticta,* possibly new; a very serious, widely spread, *sweet-potato disease,* possibly due to *Oospora,* which seems always to be present; the occurrence of the alga-like fungus *Rhodochytrium,* which seems to be everywhere on ragweed, though never collected on this plant heretofore and collected only once before in North America and only twice in the world.

Other interesting diseases which have come under our observation are a *fig rust;* a *privet disease* due to fungus attack upon the roots, resulting fatally to the plants; a peanut *Cercospora,* which is quite destructive; a *vetch Colletotrichum,* which seems to be new, and a *rot* of *tuberose bulbs,* which caused the loss of about 200,000 bulbs to one grower. This last disease has been found to be due to a species of *Penicillium.*

MELON AND TOBACCO WILTS.

Work has been continued on the lines of preceding years, looking to control of the melon and the tobacco wilts through the development of resistant varieties.

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PLANT-DISEASE SURVEY.

This work is carried on in co-operation with the National Bureau of Plant Industry. Hundreds of letters have been sent to farmers throughout the State, in order to ascertain the prevalence of certain diseases of plants and to secure information concerning their distribution. The results of this work will be summarized and published later.

Several identifications of seeds, weeds and fungi have been made and a few bacteriological water examinations have been completed.

CORRESPONDENCE.

Numerous inquiries concerning plant diseases and other botanical questions have been received and answered. In all, several thousand pieces of mail matter have been sent out by this Division.

During the year, J. C. Temple, assistant in Soil Bacteriology, a most efficient worker, has resigned to assume charge of the Department of Soil Bacteriology at the Georgia Experiment Station, and has been succeeded by P. L. Gainey, who is doing able and conscientious work.

Respectfully submitted,

F. L. Stevens,
Biologist.

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REPORT OF POULTRYMAN.

I beg to submit the following report of the work in the Poultry Division for the year ending June 30:

During the year experiments have been conducted in feeding for profitable egg production, in breeding for increased egg yield, in determining the advisability of supplying moisture in incubators and of disinfecting incubators before each hatch. The studies in in- and line-breeding have been continued.

FEEDING EXPERIMENTS.

Feeding work this year has been largely along the line of comparing cotton-seed meal and meat meal as sources of protein for laying hens.

When this work was started during the summer of 1908 it was not known what effect cotton-seed meal would have on the health of the hens. All that was known was that for some of the larger animals it is a valuable feed, while for others it cannot be fed except in small quantities and for limited periods without detriment to the health of the animals.

In order to test this, it was fed to several pens of fowls for three months in quantities ranging from 10 to 20 per cent of the total ration. No bad effects to the health of the fowls resulted from feeding any of the rations.

On December 1st fourteen pens of fowls were used to continue this work; five of these were fed rations which contained cotton-seed meal; and nine on rations containing meat meal.

The meat meal used was much richer in protein than is usually found in products of this class, as analyses showed it to contain 86 per cent protein and 7 per cent fat. It was, however, deficient in ash when compared with animal meal and beef scrap, which are commonly used in poultry feeding. These latter feeds contain more or less bone, which supplies the ash.

It had been thought that part of the benefit resulting from the feeding of protein from an animal source was due to the mineral matter generally found in these products, and as this element was lacking in the meat meal used, we added bone meal to some of the rations containing both meat meal and cotton-seed meal. Although these experiments have not been completed, it might be well to mention some of the points that the results seem thus far to indicate:

1. Fowls do not relish cotton-seed meal as well as meat meal, and therefore do not eat freely of mash containing cotton-seed meal.

2. Pullets fed on a cotton-seed meal ration do not develop as rapidly or start to lay as soon as those fed on a ration containing meat meal.

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3. Hens have done better than pullets on rations containing cotton-seed meal.

4. The addition of bone meal to a meat-meal ration reduced the cost of egg production and increased the size of stock.

5. The addition of bone meal to cotton-seed meal ration did not reduce the cost of production, due probably to the small amount of cotton-seed meal mash eaten.

The results obtained even from the best rations show that if the farmer is to secure the greatest profit from his hens he must take full advantage of his ability to give his hens a good range on a green crop from which they can obtain a large part of their food at very small cost.

In order to determine if the farmer can profitably feed the more concentrated and higher priced feeds, such as meat meal and beef scrap, and, if so, in what proportion and at what time of the year, we propose to put out several pens of fowls on free range, so that different rations can be tested under conditions similar to what the farmer has.

BREEDING FOR INCREASED EGG PRODUCTION.

In this work the progress made has not been as great as had been hoped for. The plan generally recommended for the improvement of both animals and plants, of repeatedly selecting the best producers to breed from, does not appear to give as good results in egg production as in some other lines of work. In a great majority of cases it has been found that the daughters of our best layers are among the poorest layers. In three years' work along this line only one female has been found which has shown any marked power to transmit good laying qualities to her offspring. Neither this hen nor her daughters have been the heaviest layers of the flock, but better average results have been secured from this family than from any other.

From our experience it has been found that it is more necessary to know the breeding quality of our hens than their capacity to make a large yearly record, and that the best progress will be made by selecting individual proved breeders, and through the individual establishing families, rather than by a continued selection of the heaviest layers of indiscriminate breeding.

INBREEDING.

The work in inbreeding, as outlined in last year's report, has been continued. Five pullets from one of the best hens were selected from last year's breeding. Two of these were mated with their own sire, two with a cock of the same line of breeding, but not closely related, and one with a cock of an entirely different line of breeding.

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INCUBATION.

The work started last year in testing the value of supplying moisture to the incubator and in disinfecting each incubator just before putting in eggs has been continued.

Disinfecting the eggs with a 10 per cent solution of zenoleum has also been tried. This solution was found to be too strong, as it injured the hatching quality of the eggs.

The use of a sand tray in the bottom of the incubator to supply moisture has given good results, the percentage of chicks which died in the shell being materially reduced. Some incubator operators have questioned the value of this method of supplying moisture in machines when the ventilation is from the top downward. By the use of hygrometers we found that the use of the sand tray raised the relative humidity an average about 10 per cent above that of similar machines in the same room without the sand tray.

Added moisture and disinfection are now being used in the general hatching work of the Station, and it is believed that the disinfection can be extended to the brooder as well with good results.

BROODING.

Both the fireless and heated brooders have been used with good results.

Good, strong, vigorous chickens can be raised in brooders without artificial heat, but for the first week they need more attention than do those reared in the heated brooder. Chicks do not learn to go back into the fireless brooder as quickly as they do in the heated ones, and if left to themselves are apt to stay outside and become chilled. On account of this extra care there is not so much saving in labor as some claim, but there is a very great saving in the cost of equipment necessary to raise the chicks in the fireless brooder, as any handyman can make the necessary box in a few minutes.

GENERAL WORK.

The demand for improved stock for breeding purposes and eggs for hatching continues to increase, this demand being about one-third greater than during the previous year.

The increased price of poultry and eggs, together with the awakening of the farmers to the fact that it pays to keep good stock, are largely responsible for this.

Along with this desire for better stock has come a demand for information as to the care and management of poultry, which has largely increased the correspondence of this Division.

Respectfully submitted,

J. S. JEFFREY,
Poultryman.

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REPORT OF HORTICULTURIST.

The following is a report of the work of the Horticulturist for the year ending June 30:

DOUBLE FLOWER OF BLACKBERRY AND OF DEWBERRY.

Work on double flower or rosette has consumed most of the time of the Horticulturist during the year. A preliminary study of the trouble was made during the summers of 1907 and of 1908. The experimental work was started during the past spring.

Only a small amount of the double flower appeared in the Wilson blackberry plat this spring; this was expected, as the trouble is usually not very common until the plants are two or three years old. No double flower has appeared in the Lucretia dewberry plat.

During the spring, observations were made on 23 varieties of blackberries and on 14 varieties of dewberries. A careful study is also being made of the structure of the double flowers, including the rosette-like growth of the stems and leaves and also of the flowers themselves. The double flower, so far as has been observed, never produces any fruit. Many of the stamens are defective and the ovules and druplets do not develop. This work will be extended and continued during the coming year.

During June of the present season experiments were begun to determine what effect spraying, pruning, and picking off the leaves would have on the development of double flower.

SELF-STERILITY IN DEWBERRIES AND IN BLACKBERRIES.

The experimental part of this work was started this spring. About 500 flower clusters of different varieties of dewberries were covered with paper bags to determine what varieties will set fruit without cross-pollination. We are confining ourselves this year to the following eight varieties of dewberries: Austin, Chestnut, Cox, Manatee, Premo, Rogers, San Jacinto, and White. Some interesting and very decided results were obtained during the spring. This work will be continued.

A careful study will be made of the character of the flowers of the Premo dewberry, which seems to be notably self-sterile. This is to determine what really is responsible for the self-sterility, whether it is due to defective stamens or defective unfertile pollen or whether the pollen matures at the wrong time.

The Horticulturist recently published a Bulletin on the Origin and Importance of the Scuppernong and Other Muscadine Grapes. This publication has aroused much interest in this subject.

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WORK WITH PLUMS.

Work was started during the spring to determine whether brown rot can be controlled in Japanese plums by thinning the fruit and spraying with the self-boiled lime-sulphur mixture.

Respectfully submitted,

F. C. Reimer,
Horticulturist.

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REPORT OF ANIMAL HUSBANDMAN.

I beg to submit the following report of the work carried on by the Animal Husbandry Division for the year ending June 30:

The experiment designed to determine the value of fermented cotton-seed meal for hogs has been completed and the results have been reported in Bulletin 200, Feeding Fermented Cotton-seed Meal to Hogs. The experiment is summarized as follows:

Corn alone proved to be an undesirable ration for growing hogs, causing small gains and unthrift. This condition was more marked, owing to the fact that the lot was closely penned, without pasture; yet the other lots, similarly confined, made relatively larger gains.

Fermented cotton-seed meal can be fed in small quantities for limited periods with good results. The results indicate that seventy-five to ninety days is the limit of satisfactory feeding. This would depend, however, on the age and condition of the hogs, the supplementary feeds, and the proportion of cotton-seed meal fed.

Lot 3, fed a combination of corn and cotton-seed meal, in the proportion of four to one, made larger and cheaper gains for the first ninety days than the lot similarly fed on corn and linseed meal. This would seem to indicate that, when possible, cotton-seed meal should be used, since it contains a larger percentage of protein and sells for about one-fourth less per ton than linseed meal.

Farmers would, according to the results of this experiment, be safe in feeding fermented cotton-seed meal to 75-pound shoats in quantities ranging from one-sixth to one-fifth the total ration, by weight, for a period of seventy-five to ninety days.

The feeding of the four lots of hogs during the first period was more profitable when one part of cotton-seed meal was added to the ration of four parts corn than when corn alone or corn and linseed meal in combination were fed. In the case of linseed meal, however, the greater cost of gain was due to the high price of the feed, and not so much to its lack of efficiency in making gains. Barring this one factor and the possible danger in feeding cotton-seed meal, the two feeds, according to the results of this experiment, are approximately the same in feeding value when fed for the time stated.

With corn and cotton-seed meal each costing approximately $28 per ton, the results show clearly in favor of the combined corn and cotton-seed meal ration, considering always the limitations given as to the amount fed and length of feeding period. While Lots 2, 3 and 4 had a somewhat larger ration than Lot 1, the larger gains during the first period were sufficient to considerably overbalance this factor.

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The practical application of these results would not be to feed under the conditions here described, but rather to feed the corn and cotton-seed meal in connection with grazing crops, which can be produced so abundantly by North Carolina farmers.

When fed with judgment, cotton-seed meal can be made a valuable adjunct to corn as a ration for hogs. It is the cheapest commercial concentrate for the Southern farmer and hence should not be entirely ignored in swine production.

An experiment to determine the value of cotton-seed meal as a feed for horses and mules is in progress. In this it is designed to determine the following:

1. The possibility of using cotton-seed meal as a supplementary feed to corn for work horses and mules.
2. The amounts and conditions under which it could be most satisfactorily fed.
3. The economy of the ration.
4. The effect on the health and condition of the animal.

The experiment was started April 6, 1908, and the meal has been fed continuously to the present. The results secured indicate that cotton-seed meal can be made a valuable adjunct to the ordinary ration for horses and mules, when fed properly. From 1 to 1½ pounds per animal per day have been fed with apparent satisfaction. The meal is most satisfactorily fed, however, when thoroughly incorporated with corn and cob meal, bran, brewers' grain, or some other feed of like consistency. It is not possible to feed the meal in conjunction with ear-corn with satisfaction. To feed cotton-seed meal satisfactorily the feed which forms the basis of the ration should be of such a nature as to permit of the meal being mixed with it thoroughly.

Close observations made on the work-stock, both in the barn and in the field, have revealed no apparent harmful results. This experiment will be continued to study other phases of the problem.

At the beginning of the year an investigation was started to determine the cause of the harmful effects noted when cotton-seed meal is fed to hogs and to isolate the toxin, if such it is.

This work is being carried on jointly by the Animal Husbandry, Veterinary and Chemical Divisions. Hogs and guinea pigs are being used in the work. The use of guinea pigs makes it possible to use in the investigations various parts of cotton-seed meal prepared chemically, which would not be feasible were large hogs used exclusively. Although definite results cannot be given at this time, the work is progressing satisfactorily. The work has gradually increased, as new phases of the work developed.

Along with this work, grazing experiments with swine are being conducted to determine the value of the many forage crops that grow

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well in North Carolina. The principal crops used so far are cowpeas, soy beans, crimson clover, sweet potatoes, peanuts, rape, Canada field peas, oats, and rye.

During the year a comparatively large number of inquiries have come to the Animal Husbandman regarding feeding, breeding, and management of live stock.

On the Station farm a number of improvements have been made. The equipment for carrying on the swine experiments is fairly complete. Additional farrowing pens, colony houses, a dipping tank, and pastures have been provided.

Respectfully submitted,

R. S. CURTIS,
Animal Husbandman.

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REPORT OF DAIRY HUSBANDMAN.

The main work in this Division consisted of a study of the relative economy of narrow and medium rations for cows under North Carolina conditions. This work was prompted by the relative cheapness of cotton-seed meal, which suggested the wisdom of feeding larger quantities of this material than has hitherto been the custom. Cotton-seed meal is very rich in protein, and rations containing a large amount of it will have a very narrow nutritive ratio—much narrower than is ordinarily recommended for cattle feeding.

The narrow ration fed consisted of five parts cotton-seed meal, four parts wheat bran, three parts corn meal and 50 pounds of corn silage. This ration had a nutritive ratio of 1:4. The medium ration was the same as the narrow, except that 2½ pounds of cotton-seed meal were replaced by 2½ pounds of corn meal, giving this ration a nutritive ratio of 1:5.7.

The results of this experiment were strongly in favor of the narrow ration, but it was thought best to duplicate the experiment in order to allow more positive conclusions to be drawn with reference to the wisdom and practicability of feeding a narrow ration.

The duplicate of the above experiment is now in progress.

A Bulletin on the Manufacture and Marketing of Cottage Cheese, Skimmilk-Buttermilk and Ice-cream was published during the year.

The facilities of the Dairy Division are excellent for the prosecution of effective Station work next year, and five new lines of investigations are already in progress.

Respectfully submitted,

JOHN MICHELS,
Dairy Husbandman.

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REPORT OF ENTOMOLOGIST.

The following is a brief statement of the work of the Entomological Division for the year ending June 30:

An investigation of the life-history and habits of the harlequin cabbage bug (terrapin bug), *Murgantia histrionica,* commenced in April, 1908, and was continued throughout most of the year. (A full account of this investigation, together with remedial suggestions, will be found among the Scientific Papers in this Annual Report, under the headings, "Suppression of Terrapin Bugs" and "Spring Destruction of Terrapin Bugs.")

Some attention has been given to a study of the life-history of the cabbage webworm, *Hellula undalis.*

The common little red-house ant, *Monomorium pharaonis,* became very abundant last August in the agricultural building, and an attempt was made to eradicate them, or at least to devise some means of preventing their presence in undesirable places. For nearly four weeks this work was continued with partial success, by collecting thousands of the ants on sweetened baits and by attempting to attract them to poison mixtures. The sweetened baits served to trap thousands of ants, but the poison baits were of little if any value.

It was demonstrated that ants may be kept off laboratory tables, desks, shelves, etc., by the use of a saturated solution of bichloride of mercury, one application being effective for several weeks, except for an occasional stray individual. Any tape, made by soaking strips of cotton cloth in the solution, may be tied around the legs of tables, chairs, etc., and serves to repel the ants for a considerable time.

The corn weevil problem, mentioned in my last report, has been conducted mainly along the line of fumigation. Some field observations have shown that corn may become infested as early as August, while standing in the field. The fumigation experiments have shown that the usually recommended remedy, carbon bisulphide, is not effective under ordinary farm conditions.

The fumes of burning sulphur were tested in the spring of 1908 and again during the past winter. The results proved this to be an effective remedy for killing corn weevils, but it was found to be impractical because it affected the germinating power of the corn; even a smaller amount of sulphur fumes than was necessary to kill the weevils materially reduced the germination of the corn.

Some work was carried on during February with good results in combating San José scale by means of the lime-sulphur wash. The orchard in which the studies were made, as it was badly infested, serves as a good illustration of the benefit derived from thorough spraying with this wash. The apple crop this season has been large

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and has been kept quite free from codling-moth worms, *Carpocapsa pomonella,* by two sprayings just after the blooming period with a mixture of 3 pounds of arsenate of lead in 50 gallons of Bordeaux mixture, the latter being used to prevent leaf diseases.

Press Bulletins on Fall Destruction of Terrapin Bugs and Spring Destruction of Terrapin Bugs, and a regular Bulletin on Corn Weevils and Other Grain Insects have been prepared by the Entomologist during the year.

Respectfully submitted,

R. I. SMITH,
Entomologist.

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REPORT OF VETERINARIAN.

I beg to submit a report of the work of the Veterinary Division for the year ending June 30:

The major part of the work has been given over to a study of the toxic effects of cotton-seed meal when fed to swine and guinea pigs. Both of these have been found to be quite susceptible to the ill effects of such feeding.

Daily observations have been made on nearly all of the animals fed, to determine, if possible, specific symptoms of the derangement produced by cotton-seed meal. With a number of the swine daily records were kept of weights, temperatures, pulsations and respirations. At frequent intervals blood readings were made, estimating amount of total solids, numbers of red and white corpuscles, the per cent of hemoglobin and specific gravity.

Post-mortem examinations have been made of all animals which died of cotton-seed meal feeding. In a number of instances weights were taken of various organs to compare with total weight, also portions of tissues were preserved for sectioning and for microscopical examination.

During the first half of the year work was carried on with the Bacteriological Division in an attempt to determine some of the poisons and their causes developing in milk. Samples of milk were inoculated with dirt and germs from various sources, and after a lapse of sufficient time for abundant germ growth the infected milk was injected into guinea pigs. Daily observations were taken, and upon the death of pigs post-mortem examinations and attempts to isolate germs from the blood were made.

During the year there were a large number of inquiries concerning hog cholera, and at one of the larger winter resorts, where the disease had just developed, we undertook to control its ravages by the production and use of hog-cholera serum, as advised by the National Bureau of Animal Industry. The owner had lost during the previous year nearly all of his swine except a few which recovered from the disease, and these afforded material necessary for preparation of the serum. The hogs were isolated as far as possible to delay or prevent infection until the serum could be produced, requiring some three weeks, according to the method pursued. Nearly one-fourth of the 200 head were sick or dead by this time, but after the injections of serum were made very few others became sick. As a curative agent after the symptoms of the disease developed it was found to be of little if any value, such as other investigators have observed, but its effect in preventing the trouble in those not infected was very marked. Some co-opera-

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tive work with the State Department of Agriculture is being undertaken to further prove the efficiency of this serum in preventing and controlling hog cholera.

Internal parasites, being extremely common in pigs and shoats reaching the local market, turpentine and thymol are being compared as to their efficacy in freeing grossly infested shoats of worms.

A number of specimens have been received at the laboratory for examination, both bacteriologically and pathologically.

A marked increase in the number of inquiries concerning diseases in general has been noted.

Respectfully submitted,

G. A. ROBERTS,
Veterinarian.

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RECEIPTS AND EXPENSES.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATIONS, 1908-1909.

DR.

To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ending June 30, 1909, under Acts of Congress, approved March 2, 1887, and March 16, 1906:

Hatch Fund	$15,000.00
Adams Fund	11,000.00

CR.	*Hatch Fund.*	*Adams Fund.*
By Salaries	$7,313.88	$8,272.76
Labor	2,203.45	1,181.09
Publications	662.56	.....
Postage and stationery	294.12	.....
Freight and express	84.29	.....
Heat, light, water and power	39.78	.....
Chemical supplies	.....	409.91
Seeds, plants and sundry supplies	565.33	223.34
Fertilizers	519.57	.....
Feeding stuffs	901.47	.....
Library	23.98	83.40
Tools, implements and machinery	373.65	.....
Furniture and fixtures	530.40	.....
Scientific apparatus	.....	171.75
Live stock	464.00	389.90
Traveling expenses	258.52	.....
Contingent expenses	15.00	.....
Buildings and land	750.00	267.85
Total	$15,000.00	$11,000.00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1909; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $26,000, and the corresponding disbursements $26,000; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress, approved March 2, 1887, and March 16, 1906.

(Signed)
J. T. ELLINGTON,
O. L. CLARK,
T. T. BALLENGER,
Auditors.

(Seal.)

Attest: A. F. BOWEN, *Custodian.*

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SCIENTIFIC PAPERS.

EFFECTS OF DIFFERENT FERTILIZING MATERIALS UPON THE MATURITY OF COTTON.

By C. B. WILLIAMS.

In fertilizer experiments which have been conducted at the North Carolina Station farm on a poor soil of the cecil sandy-loam type, deficient in organic matter, during the past five or six years, it has been observed frequently that the same variety of cotton planted on the same kind of soil and worked by identical methods matured differently on different plats, it being quite marked in some cases. From results secured at the Red Springs, Edgecombe, and Iredell Test Farms of the North Carolina State Department of Agriculture during two years, the writer made the same observations. These data and the deductions therefrom were published in September (1906) Bulletin of that Department. As results have been secured from coarse sandy, fine sandy loam, sandy-clay loam and tenacious clay soils for two to five years, it will be noted that the observations made and results secured have embraced many years' data and have covered a wide range of soils located under quite varying climatic conditions:

At the Station something like thirty tests have been conducted in which fertilizing materials were combined in different proportions and used in different quantities per acre, and in all cases a hastening of maturity was effected. On the unfertilized plats in all tests during all the years it has been found that in most cases the larger the yield the greater the combined percentage of seed cotton open at the first two pickings. At the end of the second picking there was but little difference, relatively, between the percentages of seed cotton open on those plats which received different quantities of fertilizer and different fertilizer combinations; but on these there was something like 50 per cent more open, as an average, than was on the plats which received no fertilizer application, but which had otherwise been subjected to the same treatment as the fertilizer plats. From the unfertilized plats about 75 per cent of the cotton was picked at third and fourth pickings; while those receiving an application of commercial fertilizer only had about 60 per cent of the crop left to open at these pickings, except in the case of the plat which received a mixture of 48 pounds of manure salt and 78 pounds of dried blood per acre, which had, on an average, 68.6 per cent. As showing the seasonal effect, especially of drouth, it will be found that by contrasting the results secured during the years 1904 (with an excess of .91 inch of rain during the months of August, September, October, and November) with those of 1905 (which had 3.45 inches deficiency from the normal for the months of August, September, October, and November, taken together, and 1.52 inches below normal for the month of November), it was found that the average percentage of total crop open on four unfertilized plats at the fourth picking was much greater in 1905 than in 1904.

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EFFECTS OF CARRIERS OF PHOSPHORIC ACID.

As carriers of phosphoric acid, acid phosphate, basic slag and finely ground phosphate rock have been tested, and all have been found to hasten the maturity of cotton, as shown by the percentage of seed cotton open at first and second pickings. In fact, the hastening of the maturity was decidedly more marked from phosphatic fertilizing materials than from carriers of potash and nitrogen tried. Increasing the quantity of phosphoric acid derived from acid phosphate with normal amounts of potash and nitrogen was attended by a gradual increase in the percentage of total seed cotton open at the first picking.

Acid Phosphate.—When 196 pounds of acid phosphate was added to an application consisting of a mixture of 48 pounds of manure salt and 78 pounds of dried blood, there was almost 13 percentage increase in seed cotton open of total crop at the first picking and more than 7 percentage increase at the end of the second picking. This application also gave 22 at the first picking and 12 per cent at the end of second picking more of the total yield open than was secured from the adjoining plat which had received no fertilizer treatment.

Basic Slag.—Basic slag was found to hasten maturity even more than acid phosphate, as was shown by practically one-half of the cotton being open at the first picking on the plat which received an application of this material in connection with normal quantities (48 pounds of manure salt and 78 pounds of dried blood) of manure salt and dried blood. On the plat to which phosphoric acid, in connection with normal application of potash and nitrogen, was supplied from acid phosphate, it was found that about 12½ per cent less of total cotton opened at the first picking than did on the plat from which the phosphoric acid in equal quantities was furnished from basic slag under the same conditions. When this latter material was applied in the drill in connection with a ton of stable manure per acre, the effects upon hastening maturity were markedly reduced.

Phosphate Rock.—Where high-grade finely ground phosphate rock as a carrier of phosphoric acid was used at the rate of 274 pounds per acre (four times normal phosphoric acid) in connection with a ton of stable manure, and both were applied in the drill, it was noted that the percentage of total seed cotton open at the first picking was about 35 per cent and at the end of the second more than 20 per cent greater than on an unfertilized plat adjacent.

EFFECT OF CARRIERS OF NITROGEN.

Carriers of nitrogen used in fertilization, such as dried blood, nitrate of soda, etc., have been found to hasten the maturity of cotton, but not anyways near to the extent that carriers of phosphoric acid do. The effect of the common nitrogen carriers seems to be felt only at the first picking, as there is no evidence from results secured that they affected the percentage of total crop open at the second picking. When used with normal amounts of acid phosphate and manure salt, increasing the amount of blood, as the carrier of nitrogen, was attended by an increase in the percentage of total crop open at the first picking, up to 200 to 300 pounds per acre of the blood.

Dried Blood and Nitrate of Soda.—When 78 pounds of high-grade dried blood was added to normal quantities of acid phosphate (196 pounds) and

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manure salt as a fertilizer application, the percentage of total crop open at the first picking was increased 3.3 per cent. Where in normal applications the amount of blood was reduced by one-half and an amount of nitrate of soda, equivalent in content of nitrogen to the reduction, was used as a side dressing and applied early in July, it was observed that the percentage of total crop open at the first picking was greater, generally, than in those cases where the whole of the normal application of nitrogen was derived from dried blood. When one-fifth of the nitrogen was derived from nitrate of soda and the remaining four-fifths came from dried blood, there was a rather marked increase in the percentage of total crop open at the first picking. When the nitrogen, in connection with normal quantities of potash and phosphoric acid, was derived from blood, one-half of which was applied at planting and the remainder reserved as a side dressing and applied early in July, it was observed that a larger percentage of total crop opened at the first picking than did where nitrate of soda was used as the carrier of nitrogen and which was divided and applied in the same way.

Cotton Seed and Stable Manure.—With cotton seed as a carrier of nitrogen and applied in the drill at planting, the effect upon maturity was about the same as where dried blood was used, while in the case of stable manure there was a material increase in the percentage of total crop open at the first picking, but showed no difference at the second picking.

EFFECT OF CARRIERS OF POTASH.

Manure salt was the only potash-bearing salt used. It was found, when used at the rate of 48 pounds per acre, to hasten the maturity of cotton but slightly. To be sure, the amount here used was quite small, and marked results were not expected where so small a quantity of any fertilizer material was used. Where one-half, twice, and thrice this quantity of manure salt was used in connection with normal amounts of phosphoric acid and potash, it was found that as the proportion of potash increased the percentage of total crop open at the first picking gradually diminished, except for the year 1907, August of which had about three inches less rainfall than normal.

EFFECTS OF LIME.

Slaked lime applied alone during the spring of 1903 and 1907 did not seem to increase the maturity of cotton in any year, as shown by the percentages open at the first and second pickings being about the same as for the unfertilized land; but, when used in connection with a normal application of a mixture of acid phosphate, manure salt, and dried blood, a marked hastening in maturity was noted. At the first picking, on an average, the addition of air-slaked lime at the rate of 1,000 pounds per acre every four years to a normal application of a complete fertilizer, resulted in an increase of more than 11 per cent of the total crop maturing than of the cotton planted on the plat receiving a normal application alone.

EFFECT OF DIFFERENT QUANTITIES.

It has been observed for the types of soil studied that increasing the amount of the application per acre of a fertilizer analyzing 7 per cent available phosphoric acid, 2½ per cent nitrogen, and 2½ per cent potash, from

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200 to 800 or 1,200 pounds, that such an increase was accompanied generally by an increase in the percentage of total seed cotton of whole crop open at the first picking.

From the data used in preparing this paper, the following tentative deductions may be made relative to the influence of fertilizer upon the growth of cotton:

1. Fertilization with ordinary applications of commercial fertilizers hastens maturity.

2. Sandy and sandy-loam soils, whether fertilized or unfertilized, yield larger percentages of total cotton open at the first two pickings combined than do red-clay soils.

3. Heavy phosphoric acid ($N P_3 K$) fertilization on sandy and sandy-loam soils and medium heavy ($N P_2 K$) applications of phosphoric acid from basic slag have produced the largest percentages of total seed cotton open at the first picking.

4. Normal ($N P K$) fertilization yields on both sandy and red-clay soils a larger percentage open at the first picking than high nitrogen ($N_3 P K$) applications.

5. High nitrogen ($N_3 P K$) applications generally yielded on all types of soil studied larger percentages of total yield open at the first picking than high potash ($N P K_3$) applications.

6. Air-slaked lime alone does not hasten maturity, but when used in connection with commercial fertilizers it augments their influence in hastening maturity, as shown by percentage of cotton open at first picking.

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SOME FACTS CONCERNING THOSE CHARACTERS OF THE CORN PLANT ASSOCIATED WITH YIELD AND FACTORS WHICH INFLUENCE THEM.

By C. B. WILLIAMS and W. C. ETHERIDGE.

With corn, as with other crops, yield is determined by environment and by certain characteristics which the individual plants may possess. Without a favorable climate, good soil, and thorough tillage, no strain of corn can produce maximum yields any more than, with these supplied, can the greatest yields be secured where seed bred and selected in the most intelligent manner are not used. In consideration of these facts, it is deemed not inappropriate at this time to consider somewhat in detail some of those characters of the corn plant which seem to be associated intimately with high yielding capacity. The deductions made are largely from data secured with some sixty to seventy varieties of corn, many of them grown each under four different conditions—two of fertilization and two of distancing the hills in the rows.

I. CHARACTERS ASSOCIATED WITH YIELD.

Prolificacy in Ears.—As prolificacy is influenced by soil and climatic conditions, increasing the yield of any variety is usually attended by an increase in its prolificacy within narrow limits; and the larger the yield in grain of a variety, the larger the percentage of ear of total plant, the heavier the grain and the less pounds of ear-corn required to shell a bushel.

In variety tests on the Station farm during the past six years, as it has been found to be a pretty general rule that those which have averaged the largest yields of grain per acre were those possessing a decidedly strong tendency to produce more than one ear per stalk, it would seem to be safe to infer that the prolificacy of stalks in ears should be given prime consideration in selecting seed corn. In the Station tests it has been found that Sanders' Improved, a fairly prolific variety, has yielded as an average of five years 6.8 bushels more of shelled corn per acre than Holt's Strawberry, a good one-eared variety; while Biggs' Seven-ear, another prolific variety, has outyielded Holt's Strawberry 4.4 bushels as an average of three years' tests. Ordinarily, for the better grade of improved farming lands, it is not felt that it would be wise to select seed from stalks bearing more than two ears. It is believed that the richer the land on which the corn is to be planted the greater the prolificacy in ears that may be selected for with profit. On the poorer grades of land it is suggested that, until its yielding capacity has been increased, the best one-eared varieties be grown. Too great a prolificacy of corn to be planted on poor land may be a positive detriment to yield. The tendency of such seed will be to produce a large number of ears; and as the limited supply of available plant food contained in the soil will run quite low towards the latter part of the growth of the plants, there will usually be a large number of shoots and nubbins produced and very few ears; while, on the other hand, a one-eared variety might have given fairly good-size ears

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under the conditions; certainly it would in all probability have done better. It might be stated in this connection that, where these conditions of soil obtain, it is thought that time might be put to better advantage in growing on it soil-improving crops, such as cowpeas and clover, and defer planting it to corn until it has been considerably improved in producing capacity. It is not felt that corn can be raised profitably on very poor land.

Percentage of Grain.—Although it is essential for any variety to possess the characteristic of producing a high percentage of grain to ear for it to attain its maximum yielding capacity, yet, as other factors, such as prolificacy, size of ears, source of seed, etc., enter, the largest yields need not necessarily be expected from those varieties possessing the highest percentage of grain. As a matter of fact, the largest yields by varieties tested at the Station farm during the past five years have been secured from those which produce a medium percentage of grain; but this is not because this is an unessential of the highest possible yields, but rather seems to be due to the fact that varieties possessing the highest percentages of grain have been bred and selected largely for this quality alone, while other characteristics that might have contributed to the yields were seemingly left out of consideration to a large extent in the establishment of these varieties. Increasing the size of the ear of any variety, it has been observed, is generally attended by an increase in the percentage of grain to ear, although to some extent this is modified by season.

The best yielding varieties have been found to bear ears which shell on an average of 80 to 87 per cent grain. With the same variety there is a seasonal variation of a fraction of a per cent to 2 to 4 per cent, or even more.

Size of Ears.—Large-eared varieties usually have a relatively low percentage of grain to cob, and are, as a rule, less productive of shelled corn per stalk than the more prolific varieties. Although, taking everything into consideration, where corn is gathered by hand, as is done in many portions of the South, it will usually be a little easier and slightly cheaper to gather and handle the same acreage of large-eared corn than of corn with smaller ears, when the yield of shelled corn per acre for both are the same, yet, quite frequently, from a financial standpoint, it will be better for the farmer to use seed of a variety possessing a relatively small ear, because of the greatly increased yield of grain per acre that would result from the use of such seed. Within reasonable limits, it should not be so much the size of the ears that should govern in the selection of a variety for seed purposes as the persistency of the seed of the variety to withstand adverse conditions and to produce large yields of shelled corn per stalk and hence per acre. However, within the same variety it will usually be advisable to choose for seed those ears, other characteristics being equal, that are of the average or slightly above the average in size for the variety.

The size of the ear of a variety is not determined solely by heredity, but is greatly influenced by climate, season, soil fertilization, cultivation, etc.; for the more favorable these conditions are for the growth of the plants, the larger and heavier will the ears and kernels produced be at maturity; and the more unfavorable these conditions are, the smaller they will grow. In other words, if seed of the same variety were planted during the same year on both rich bottom and ordinary upland soils, it would be found at maturity,

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with a favorable season, that the corn grown in the bottom had not only produced a larger yield and greater number of ears per stalk, but had also borne considerably larger ears, and it would generally be easy for one who is at all familiar with ear types of different varieties to determine by general appearances whether a given ear had been produced on rich land or not.

It will be better to use seed of a variety having medium small ears with poorly shaped kernels in preference to one with large, well-shaped ears possessing well-formed kernels, if the former produces, under the same conditions of season, soil, and cultivation, greatly increased yields over the latter, notwithstanding the fact that it may be a little less expensive to house the latter, because the net profit resulting from the former would be much greater.

By using a variety with a strongly fixed prepotency to high yield of shelled corn per stalk—the great desideratum, after all—the size and shape of the ear and its kernels may be materially improved within a few years, through careful seed selection, with a resulting tendency to further increased yields over the original stock. It should be borne in mind clearly, however, that by developing larger and better-shaped ears and kernels of any variety, through seed selection, persistently practiced through a number of years, that only two of the many characters that contribute to high yields are improved.

Height of Ears and Stalks.—It has been found that the best yielding varieties were those which possessed a medium to tall stalk and were those which have their ears at a medium height. The varieties which had the lowest stalks and ears were those seed of which have come from the corn-growing States of the Northwest. The ears should be attached a little below the center of the stalks. Varieties which make too large a growth of stalks are generally late in maturing and are therefore far more likely to be caught by early frost in the fall than those that make a relatively small or medium growth of stalk.

Date of Maturity.—As a general thing, those varieties which mature earliest are the smallest yielders of both grain and stover, while those producing most per acre are medium to late maturing. Other things being equal, earliness in maturity of not only corn, but all other crops, is at a sacrifice of yield, as earliness and high yield are antagonistic characters, if a favorable growing season is afforded for the maturity of the later maturing varieties. Usually, also, earliness is accompanied by a high percentage of ear to stover; but this ratio is more or less influenced by season, soil, fertilization, breeding and selection. It might be stated here that with many crops, however, earliness is more essential than heavy yields; especially is this so with trucking crops, for if they do not reach maturity early in the season the best prices are not obtained. Where for any reason the season for growth is short, the best of the early varieties will give the largest yields under the conditions, but the yield will be smaller generally than would have been produced by the best of the medium and late maturing varieties had the season been sufficiently long for their full development.

II. DIFFERENT DISTANCING OF HILLS IN EQUIDISTANT ROWS UNDER DIFFERENT DEGREES OF FERTILIZATION.

Effect Upon Yield.—The optimum distancing for yield of corn, as with other crops, is governed by variety, season, soil, fertilization, cultivation,

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etc. For the same soil, the more favorable the season, fertilization, and cultivation, the closer, within limits, the planting may be done with profit, especially so with the prolific varieties. To illustrate specifically the effects of fertilization under local conditions which embody principles of wide application, it was found that as an average of the yields of 68 varieties, planting at 20 inches in the row produced 3.8 bushels more shelled corn and 563 pounds of stover per acre on highly manured land than did spacing the hills 30 inches in the row; while on the same land which did not receive but 300 pounds of commercial fertilizer per acre the yield of grain and stover was practically identical at both distancing (20 and 30 inches) and were but little more than one-half those obtained from the highly manured plats of the same acreage. With the highly manured plats, 76.1 per cent of the varieties yield most shelled corn per acre at 20-inch spacing of the hills as against 30 inches, and those which did not follow this rule were all of one-eared type. In the case of stover, 86.6 per cent of the varieties yielded most where the stalks stood 20 inches in the row on the highly manured plats. On the better manured plats, 85.1 per cent of the varieties yielded a greater value of total products (grain and stover) at 20-inch spacing in the rows. With varieties receiving an application of (cow) manure supplemented by 300 pounds of commercial fertilizer, the value of total products was $5.29 more per acre where the stalks were 20 inches than where they were 30 inches; while on the same land which received only 300 pounds of commercial fertilizer per acre the difference was, on an average, not but 23 cents, which was in favor of 20-inch distancing in the rows. From the above, therefore, it is observed that increasing the productivity of the soil by a fairly liberal broadcast coating of (cow) manure and fertilizer was accompanied by materially increased yields, over 30-inch spacing, by thinning the stalks to 20 inches, while under ordinarily poor fertilization there was practically no difference between a spacing of 20 and 30 inches of the hills in the rows, which emphasizes the importance of closer planting as the fertility of the land is increased.

Results in these experiments were secured from 68 varieties of corn grown in 4-foot rows during 1908 on poor land of the cecil sandy-loam type which would not normally without fertilization yield more than 12 to 14 bushels per acre. The land was treated in two sets in different degrees of fertilization. On one set of plats, which will be termed the "highly manured" set, 16 tons of a high-grade cow manure (the cows had been fed on cotton-seed meal and wheat bran, and no bedding was in the manure), supplemented by an application of 300 pounds per acre at planting of a fertilizer analyzing 7 per cent available phosphoric acid, 3 per cent nitrogen, and 1½ per cent potash was used; while the other set received only 300 pounds of commercial fertilizer per acre of the grade given above. This set in the discussion that follows will be called the "poorly fertilized" one.

Effect Upon Size of Ears.—Under heavy manuring, stalks which were 30 inches in the row produced ears, on an average, which were .37 inch longer and .12 inch greater in circumference than those grown on stalks standing 20 inches apart; while on the poorly fertilized plats the ears were .44 inch longer and .16 inch greater in circumference at 30-inch than those grown at 20-inch spacing of the stalks. The average length and circumference of the

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ears on the more highly manured land were .99 and .46 inch respectively greater than where the 68 varieties were grown on the poorly fertilized plats. On the highly manured land 84.6 and 68.2 per cent and on the poorly fertilized plats 79.1 and 76.1 per cent of the varieties produced ears longer and circumference of same greater respectively at a spacing of 30 inches. As an average of all the varieties, it required 122 ears to shell a bushel from hills thinned to 30 inches and 131 ears at 20 inches on the highly manured plats; while for the poorly fertilized corn, it required 166 ears at 30-inch-grown and 200 ears of that grown 20 inches in the row. On the poorly fertilized plats it required an average of 56 ears more to shell a bushell of corn than it did where the corn was produced on the better land. On the highly manured plats 72.7 per cent of the varieties required a larger number of ears to shell a bushel where the corn was grown 20 inches apart in the rows; while on the poorly fertilized plats 83.3 per cent of the varieties required most at the same distancing. On the highly manured plats it will be observed that a 20-inch distancing of the hills gave the largest yields, while stalks spaced 30 inches produced the largest and longest ears. Both higher fertilization and greater distancing between hills increased the length and circumference of the ears of two-thirds to three-quarters of all the varieties under experiment.

Effect Upon Height of Stalks and Ears.—On the highly manured plats the height of the stalks and ears were 2.30 and 1.60 inches higher respectively at a spacing of 20 inches between the stalks than at 30 inches; while on the poorly fertilized plats the stalks and their ears were 5.50 and 1.70 inches higher above the ground respectively at 30 inches. The average height of the stalks and ears under better manuring were 11.35 and 6.40 inches higher respectively than those grown on the poorly fertilized plats. Of the stalks and their ears of the 68 varieties, 67.2 and 68.7 per cent at 30 inches, and 83.8 and 69.1 per cent at 20 inches, were highest on the heavily manured and poorly fertilized plats respectively. It would seem, then, from these data that in the presence of limited quantities of plant-food in the soil an increase in the distance between stalks from 20 to 30 inches of corn planted in 4-foot rows leads to the production of a taller growth of stalks and higher attachment of ears above ground; while with the same soil fairly well supplied with plant-food from (cow) manure and fertilizer for the immediate needs of the plants an increase in the thickness of planting from 30 to 20 inches is attended by the growth of higher stalks and ears.

Effect Upon the Number of Ears and Amount of Shelled Corn per Stalk.—On the highly manured plats there were for all the varieties taken together .11 more ear per stalk at 30 inches than at 20 inches spacing of the hills in the row, and on the plats receiving only 300 pounds of commercial fertilizer .10 more of an ear on an average at 30 than at 20 inches. Contributing to these data 91.0 per cent of the varieties on the highly manured land and 86.8 per cent on the poorly fertilized plats produced most at the respective favorable distancings. The average difference between the highly and poorly fertilized plats was .15 more of an ear per stalk on the former than on the latter. The corn under better fertilization produced 27 per cent more shelled corn per bearing stalk at 30-inch distancing than at 20 inches; while that grown on land poorly fertilized, an increase of 41 per cent was secured in

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favor of the former distancing, which indicates that in the presence of limited quantities of plant-food a slight increase in the amount of space per plant is attended by a much greater increase in yield of grain per stalk than is secured on land which is more highly manured. The highly manured plats, as an average of both distancing, produced .148 pound shelled corn per bearing stalk, or an increase of 68.4 per cent more shelled corn per bearing stalk than was produced on the plats receiving 300 pounds of commercial fertilizer alone. It will be observed that increasing the distance between the hills and the fertility of the land were attended by a larger number of ears per stalk and by a marked increase in the quantity of shelled corn per bearing stalk.

Effect Upon Maturity and Stand.—The two distancing of hills studied did not seem to affect differently to any great extent the growth of the plants up to the tasseling and silking stages, yet the weight of evidence is that closer spacing of the stalks retarded the maturity by about one day, on an average. The corn on the highly manured plats tasseled and silked from three to four days earlier than on those receiving an application of commercial fertilizer alone. Better fertilization seems to lead to a more perfect stand, as is evidenced by the varieties planted on the plats which received an application of (cow) manure and 300 pounds of commercial fertilizer being 2.56 per cent better than that from seed of the same varieties planted in the same manner on the same type of soil which received only an application of commercial fertilizer.

Effect Upon the Production of Suckers.—On the more highly fertilized plats 9.48 per cent at 30 inches and 6.13 per cent of the stalks produced suckers at 20-inch spacing of hills in the row; while on the poorly fertilized plats 6.15 per cent produced suckers at 30 inches and 2.87 per cent at 20 inches. Suckers, therefore, are increased in number both by increasing the distance of the hills apart and by the addition of more plant-food to the soil. It has also been observed repeatedly that under the same conditions some varieties produce many times more suckers than do others, hence the production of these is a varietal characteristic which is influenced by fertilization, spacing of plants and other environmental factors.

Effect Upon Barrenness.—By decreasing the distance between hills from 30 to 20 inches on the manured plats the percentage of barren stalks was increased from 1.73 to 3.42 per cent, while on the poorly fertilized corn it was raised from 5.26 to 10.73 per cent. It will be noticed from these data that for both the sets the percentage of stalks barren was doubled by a decrease in the distancing of the hills in the row by 10 inches, and that the corn on the poorly fertilized plats was affected with more than three times the percentage of barrenness that prevailed on the plats receiving (cow) manure and commercial fertilizer. Therefore, barrenness seems to be decreased both by an increase in the distance between hills in the row and by heavier and more favorable fertilization.

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VARIATION OF FUNGI DUE TO ENVIRONMENT.[1]

By F. L. STEVENS and J. G. HALL.

The effects of environment, climatic condition, soil fertility, the presence of unusual chemicals, the water relation and what not upon the form and characters of seed plants are well known to the plant physiologist, and have been the subjects of numerous studies. These factors are even utilized by the practical man to bring about desired variation.

That fungi vary similarly will not be doubted by any who have had to do with fungi in artificial cultures. The kind and degree of such variation, we dare say, will be a surprise to any who have made special study of this subject.

While our knowledge of the seed plants, owing to man's long acquaintance with them, their larger size and comparative stability is considerable, yet even with them the limiting of genera, species, varieties, etc., presents difficulty, if we may judge from the rich literature upon phanerogamic taxonomy. The fungi, because of their immense number of species, variety of forms, minuteness, paucity of distinguishing characters, complexity of life-history (mostly unknown) peculiar biologic host relations (almost entirely unknown), and because of man's short acquaintance with them and their unknown but apparently vast range of variability, present as yet baffling problems of relationship and classification.

The object of the present article is to call attention to the kind and degree of environmental variation found in a few species of fungi that have been studied by the authors during the past four or five years and in some instances to analyze the causes of these variations to the end that the factor of environmental variation may be more clearly recognized as a problem of mycological taxonomy.

We shall consider these variations under the causes that produce them.

I. Density of Colonies.

Septoria petroselini Desm. var. *apii* Br. and Cav., from celery.

This fungus, when plated so that the spores lay thinly scattered, produced colonies which were ultimately black, from 1 to 2 mm. in diameter, with pycnidia of normal character; if plated so that the spores lay in large numbers per square centimeter, it produced colonies which reached a size of only about .5 mm. and became ultimately black, containing ordinary pycnidia, bearing spores in the normal way. When plated so that there were still more spores per square centimeter, the colonies never became black and no pycnidia were produced; but to the contrary, multitudes of spores were borne uncovered, in clumps upon simple hyphæ.

Septoria lycopersici Speg., from tomato.

Spores from pure culture were plated in 4 per cent pea agar in various dilutions.

[1]Read in part at the Baltimore meeting of the Botanical Society of America, December, 1908, and published in the *Botanical Gazette* 48 (1909).

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One plate developed 5 to 6 colonies per square millimeter and each colony proceeded to normal pycnidial development. Another plate developed 21 to 23 colonies per square millimeter and all proceeded to form naked conidia with no indication of pycnidia. Portions of these two plates are represented

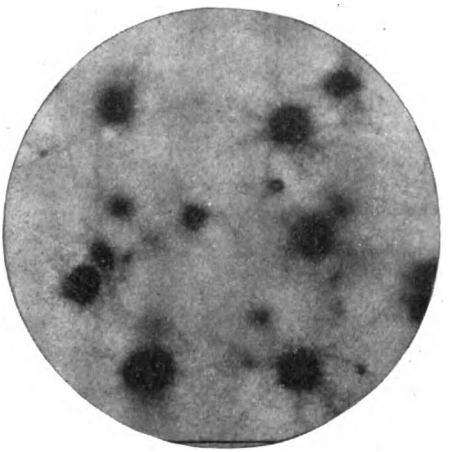

FIG. 1.—*Septoria Lycopersici* Speg., showing formation of normal pycnidia on portion of thinly sown plate culture.

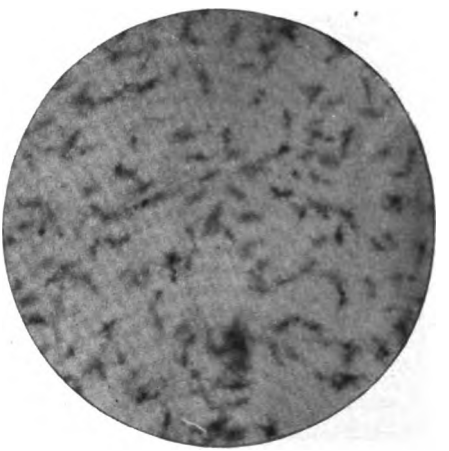

FIG. 2.—*Septoria Lycopersici* Speg., showing absence of pycnidia on thickly sown portion of plate culture; magnification same as in Fig. 1.

by photomicrographs (Figs. 1 and 2). Drawings of the naked spores showing the detail of their formation are given in Fig. 3. Occasionally plates with as many as 30 colonies per square millimeter were found with both pycnidia and naked spores.

Pycnidia not visible at the fifth day may be well formed by the sixth day and extrude masses of pink spores about the twenty-first day. Occasionally pycnidia are well developed on the fourth day. When naked spores develop they normally appear a few days later than do pycnidia, *e. g.*, a plate thinly sown on January 12, 1907, gave many pycnidia on January 15, while a thickly sown plate, under conditions otherwise precisely parallel, did not give naked spores until January 22.

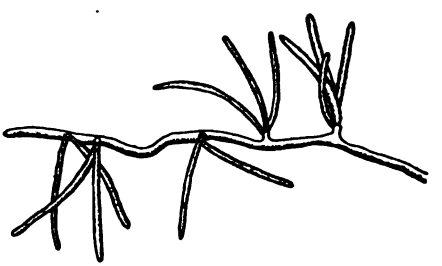

FIG. 3.—Mode of formation of naked spores under influence of crowded culture.

This septoria forms a typical determinate colony, *i. e.*, even with unlimited room, it proceeds only to a certain size of development.

Septoria consimilis E. & M., from lettuce.

When sown thinly colonies reached a size of 2 to 3 mm. in diameter; when sown thickly they became no more than .2 mm. in diameter. There was no interference with color development or formation of pycnidia by thick sowing with this species.

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With two of these septorias, thick plating, other conditions being the same, so changed their character that not only would the species be considered as different, but the fungus would be shifted from the *Sphaeropsidales* to the *Hyphomycetales* (Hyplaesa of Saccardo).

A similar change of habit is well known in the genus *Fusarium*, which in culture, crowded or not, often abandons acervulus formation, thus changing its systematic position from the *Tuberculariaceae* to the *Mucedinaceae*. The genera *Colletotrichum* and *Glocosporum* similarly abandon acervulus formation and thus suffer still greater taxonomic disturbance by moving from the *Melanconiales* to the *Hyphomycetales*.

Ascochyta chrysanthemi Stevens, from chrysanthemum.

This fungus was plated January 12, 1907. Myriads of pycnidia were present four days later; thick plating caused no inhibition of pycnidial formation, no naked spores and no constant effect upon the number of pycnidia produced.

Volutella fructi S. & H., from apple.

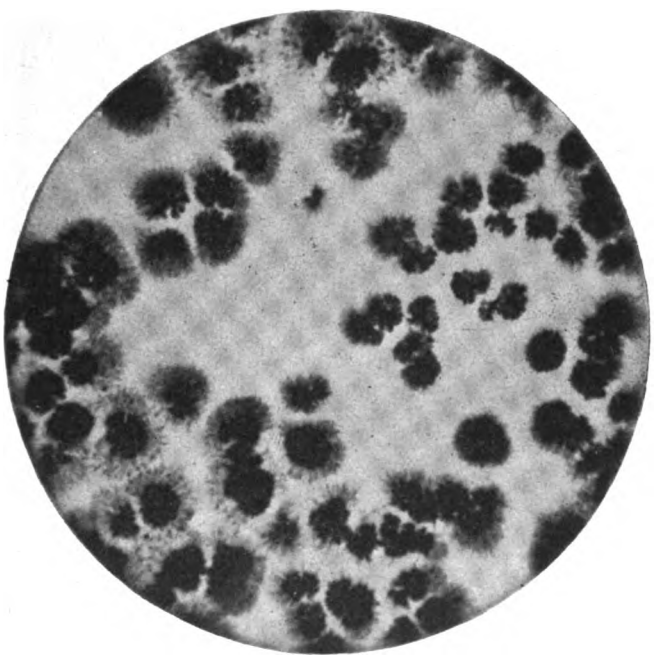

FIG. 4.—*Volutella fructi* S. and H., showing colonies on thinly sown plate culture.

Thinly sown, the colonies were large, of indeterminate growth, showing dark centers with pale borders (Fig. 4); thickly sown, growth was inhibited and their characters lost. (Fig. 5.)

Spermoedia paspali Fries, from *paspalum*.

Spores of this fungus were sown January 19, 1907, in plates giving colony densities of 90, 54, 30, 14 and 1 per square mm.

At all of these densities germination was practically 100 per cent and growth proceeded equally in all plates during the early stages. On February

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11 it was noted that all colonies which came nearly in contact were sporing. Growth then stopped. In the plates bearing only one spore per square millimeter the colonies continued to enlarge slowly and to produce many spores in the central portion, though remaining white, not attaining the usual yellow color. Deep colonies appeared like the superficial, but bore no spores. On

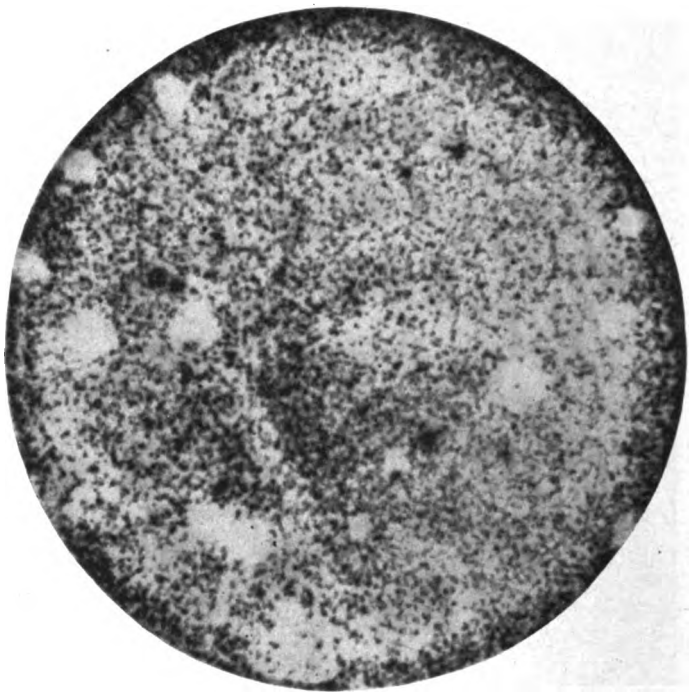

FIG. 5.—*Volutella fructi* S. and H., showing effect of thick sowing.

February 7 the colonies on thin plates (1 per square millimeter) had attained a diameter of 1.5 mm. Some of those colonies transferred to tubes continued to enlarge, became tubercular, and developed a yellow center 3 or 4 mm. in diameter. The whole colony often reached 1 cm. in diameter. Sister colonies left in the plate (1 per square millimeter) failed to so develop, and it is evident that at even this density normal development is not attained.

The colony is indeterminate in growth and in plates its size is limited by the presence of adjacent colonies.

SUMMARY REGARDING THE DENSITY FACTOR.

This factor produces different effects with the different species. It may inhibit pycnidial formation, resulting in naked spores; it may cause failure to develop color; it may limit the size of the colony; or it may be without effect.

There are many paired species of the imperfect fungi agreeing closely, except in the presence or absence of one character. These pairs often occur

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upon the same host, *e. g.*, *Septoria lycopersici* Speg. and a *Cylindrosporium* on the tomato, and *Cylindrosporium Chrysanthemi* E. & D. and *Septoria Chrysanthemi* Cav. on the cultivated chrysanthemum.[1]

Many other instances could be cited.

The lack of fixity of such a structure as even the pycnidum throws doubt upon the validity of such species as these and indicates the necessity of close comparative study.

II. Density of Mycelium: Zone Formation.

The formation of concentric zones is by many fungi one of the most conspicuous characters shown in cultures. These zones may be due to any one of many structural characters of the colony; to varying density of spore mass-

Fig. 6.—*Ascochyta Chrysanthemi* Stevens; plate culture showing that the formation of zones is not coincident with diurnal changes; ink marks show growth for three consecutive days.

ing; pycnidia grouping, mycelial branching, color, etc. It is a frequent prenomenon in nature in the fairy rings of the toad stools, the concentric markings of many leaf spots, fruit rots, etc. These effects have been attributed to

[1]Voglino, Diseases of cultivated chrysanthemums, Malpighia 15 (1902), 329–341. E. S. R. 14, 777.
[1]Halsted, Chrysanthemum leaf spot, American Florist, 10 (1894), No. 333, 263. E. S. R. 6, 311.
[1]Beach, Leaf spot of chrysanthemum, N. Y. State Sta. Rpt., 1892, 557–560.
[1]Halsted, Report of fungus disease of plants, N. J. Sta. Rpt., 1891, 233–340.
[1]Sacc. Syll. Fung. 11, 542, Nos. 3497, 3498, 3757. Tubeuf and Smith, Diseases of Plants, 478. Year-Book U. S. Dept. Agr., 1906, 507. Geneva Sta. Rpt., 14, 529. N. J. Sta. Rpt., 1894, 361.

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various causal agencies: to light relation,[1] to nutrients,[2] to agencies other than light, probably food, and to resting periods and to mycelial crowding.[3]

Ascochyta chrysanthemi Stevens.

With the fungus in question the fact that the zones are not due to light or temperature relations is apparent from the fact that they do not coincide with the fluctuations of these two factors (Fig. 6). In the colony shown, which is that of a plate culture kept at room temperature, there was daily change from warm to cool, light to dark, yet the number of rings does not coincide with the number of these changes; moreover, zones were produced in precisely the same way on plates kept constantly in the dark as in plates kept all of the time in the light, and still the same on plates kept three days in the dark and then three days in the light.

Microscopic examination shows that with this fungus the dark zone is due to a larger number of mycelial filaments, the light zone to a smaller number of threads, as is shown diagrammatically in Fig. 7. It seems that with this

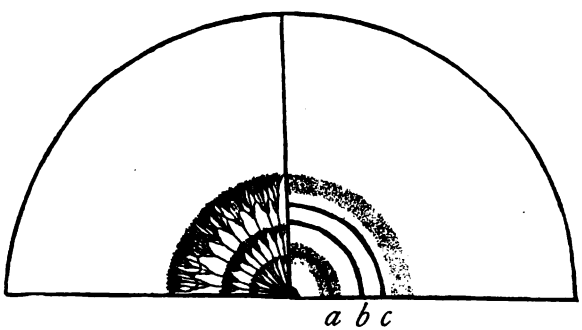

FIG. 7.—Diagram showing, at right, the zones (stippled) and diurnal marks; at left, theoretical expression of cause of zonation.

fungus the dense crowding of the filaments resulting from their repeated branching inhibits growth either by the products of metabolism or exhaustion of nutriment. There is then a period of quiescence, followed by onward growth of a few scattered hyphæ. As these outgrowing hyphæ reach beyond the inhibiting influence, they branch repeatedly until a new dense zone is formed. This process is repeated indefinitely. The rapidity of succession of zones is dependent solely upon the relation which rapidity of branching bears to rapidity of increase in length. Slow lineal growth and much branching gives many narrow zones; rapid lineal growth with infrequent branching causes broad zones.

Sclerotinia Libertiana Fckl., from lettuce.

Zonal sclerotial formation is exhibited by this fungus. (Fig. 8.) That this phenomenon may be attributed to crowding of the mycelium is indicated by the fact that adjacent colonies form more sclerotia at their points of contact. (Fig. 9.)

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[1]MOLZ, "Ueber die Bedingungen der Entstehung der durch *Sclerotinia fructigena* erzeugten." Schwarzfaule der Aepfel. Cent. f. Bak. II. Ab. 17, 175.
HUTCHINSON, "Ueber Form und Bau der Kalonieen niederer Pilze." Cent. f. Bak. II, Ab. 17, 602. Also
HEDGECOCK, Zonation in Artificial culture of Cephalothecium and other fungi. Ann. Rpt. 17, Mo. Bot. Gard., 1906.
[2]MILBURN, Ueber Aenderungen der Farben bei Pilzen und Bakterien. Cent. f. Bak. Ab. II, 13, 257.
[3]ISTVANFFI, Etudes Microbiologiques et mycologiques sur le rot gris de la vigne. Am. de l'Institut Cent. Ampel. Roy. Hongrois, 1905, 183.

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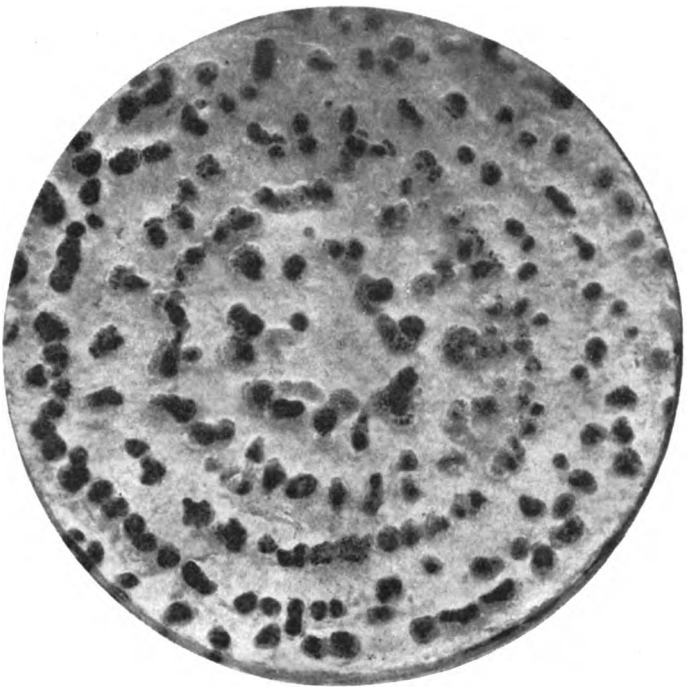

FIG. 8.—*Sclerotinia Libertiana* Fckl., showing zonal formation of sclerotia on corn meal culture.

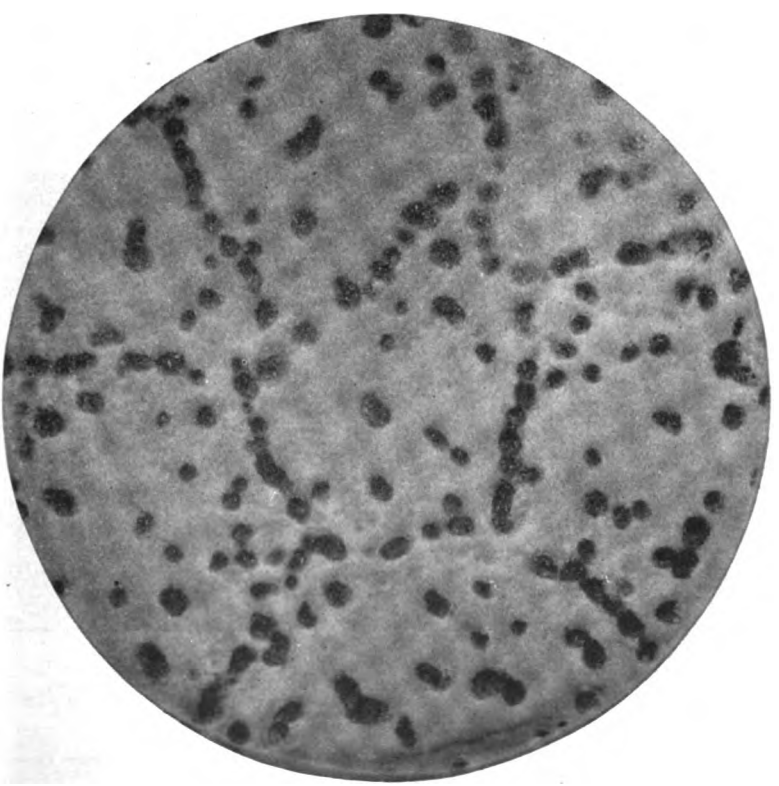

FIG. 9.—*Sclerotinia Libertiana* Fckl., showing the formation of sclerotia in greater abunda where adjacent colonies come in contact.

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SUMMARY REGARDING DENSITY OF MYCELIUM.

Zone formation in *Ascochyta Chrysanthemi* is due to crowding of mycelium, not to light or heat relation. A similar conclusion was reached by Istvanffi (Istvanffi lc.) regarding the very striking zones shown by *Sclerotinia*. The same causes may apply also with *Daldinia concentrica* and many other fungi of similar structure.

III. Chemical Relations.

Chemical relations have been studied with eleven fungi, the fungus being usually grown in agar with varying nutrients added. Occasionally other media were used. A chemical base agar (cba) was made of the following proportion:

Water	1,000 grams.
Di-potassium phosphate	2.5 grams.
Calcium chloride	.01 gram.
Magnesium sulphate	.01 gram.
Sodium chloride	2.5 grams.
Potassium sulphate	2. grams.
Agar	15. grams.

To 100 cc. of this chemical base agar were added the following materials singly or in varying combinations:

Ammonium lactate	.5 gram.
Sodium asparaginate	.25 gram.
Glucose	1. gram.
Starch	1. gram.

The tests were usually made in both plate and tube cultures.

Volutella fructi S. and H., from apple.

This fungus, when sown thin, forms large indeterminate colonies, often with numerous scattered tubercular blotches (Fig. 10).

On pure agar and cba the colonies were pale; mycelium hyaline; black tubercles very sparse.

On pea agar black tubercles were much more abundant, otherwise as on pure agar.

On cba+sodium asparaginate black tubercles were still more numerous.

On cba+sodium asparaginate+starch black tubercles were more numerous than in any of the above, and the colony was black (Fig. 11).

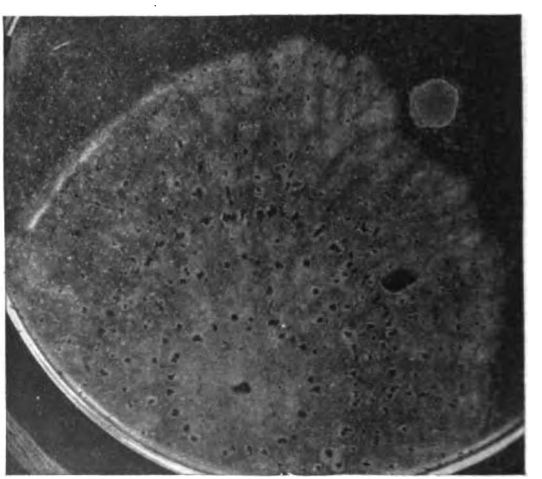

FIG. 10.—*Volutella fructi* S. and H.; colony on pea agar showing tubercular blotches, some of them in concentric rings; mycelium nearly hyaline, due to lack of carbohydrates.

On cba+sodium asparaginate+glucose black tubercles were still more numerous, so many as to be contiguous, and the whole colony was densely

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On gelatinized starch+Uschinsky's solution the mycelium was black, and some digestion of the starch was observed.

On none of the above media were spores formed, but on sterilized apple twigs spores were produced in abundance.

The differences here noted upon these different media are sufficient to alter entirely the general appearance and to shift the fungus from the Tuberculariaciae-Dematiae to the Tuberculariaciae-Mucedinae.

Coniothyrium Fuckelii Sacc., from apple.

This fungus when growing upon a medium rich in starch becomes black in its peripheral layer. Glucose fails to produce the same result. The mycelium hyaline when on pea agar, but tawny on apple agar.

Septoria petroselini var. *apii*, from celery.

This fungus fails to produce naked spores when sown thickly on celery agar, though it does so under similar conditions when upon lettuce agar.

Colletotrichum carica S. and H., from fig.

This fungus upon the different media used showed striking differences in number or setae, varying from none to abundant; number of spores varying from few to many; color, varying from pale to almost black.

On cba+growth was scant; acervuli small, setae absent.

FIG. 11.—*Volutella fructi* S. and H.; two black colonies upon cba + sodium asparaginate + starch.

On cba+ammonium lactate and cba+sodium asparaginate growth was about as in cba, except that numerous black setae were present.

On cba+ammonium lactate+starch the acervuli were larger, more numerous, with numerous large black setae.

On cba+sodium asparaginate+glucose, black setae were numerous.

On cba+sodium asparaginate+ammonium lactate there were a few setae.

Epicoccus sp. indet, from apple agar in Petri dishes.

This fungus on pure agar and cba was colorless. On cba+starch or cba+glucose there was much richer mycelial development which, moreover, took on a rich yellow color that in spots turned to pink. Sometimes black spots developed on the first of these media, but not upon the second. This fungus shows strikingly the differentiating value of starch and glucose for fungus culture.

Upon apple agar still another character developed, a rich golden color of the abundant fluccose matted aerial hyphæ. This reaction is fully as striking as the familiar rose color produced by a certain species of Fusarium.[1]

With this fungus we have absence of color in agar and cba, but rich coloring of varying hues in the presence of carbohydrates and upon apple agar.

[1]BESSEY, Ueber die Bedingungen der Farbbildung bei Fusarium, Inaug. Diss. Halle., 1904.

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Phyllosticta sp. indet, from apple agar in Petri dishes.

This fungus grew faster on agar than on cba, formed pycnidia sparsely on agar and not at all on cba.

With sodium asparaginate added the mycelium becomes very dense, with considerable aerial development, remains colorless and produces few pycnidia, and these visible only with the two-third objective. The presence of glucose led to exceedingly profuse pycnidial development, while on starch the growth was as with cba+sodium asparaginate, showing again the ability to utilize glucose, but not starch.

Alternaria sp. indet, from Lawson carnation.

This fungus, the cause of an apparently undescribed carnation disease which will be the subject of a subsequent paper, was isolated during October, 1908. There was striking difference in the color of the colony upon different media, varying from merely hyaline to dense black. The size and color of the spores was also so modified as to give much more than what is usually regarded as a specific difference.

On pure agar, cba, cba+ammonium lactate, cba+sodium asparaginate, and upon cba+ammonium lactate+sodium asparaginate, the mycelium was colorless and the colony correspondingly colorless, while upon cba+sodium asparaginate+starch and cba+sodium asparaginate+glucose the mycelium was very dark, more profuse, more freely branched, and the colony therefore of an entirely different aspect.

Spore formation proceeded sparingly, though evenly and regularly, upon pure agar, cba, cba+ammonium lactate, cba+sodium asparaginate, cba+sodium asparaginate+ammonium lactate; but very abundantly upon cba+sodium asparaginate+starch and upon cba+sodium asparaginate+glucose. Here the sodium asparaginate seems not to furnish the carbon in sufficiently available form, though starch or glucose do so to nearly equal extent.

The size, color and septation of the spores were also greatly influenced by the medium.

From carnation-agar plates the spores measured from 16 to 52 mu long by 6 to 13 mu thick, bearing from none to three longitudinal septa and from 3 to 7 transverse septa, while from the live carnation leaf the spores were from 26 to 123 mu long by 10 to 20 mu thick, bearing from 1 to 9 or often numerous longitudinal septa and from 3 to 15 transverse septa. It is seen that the spores are approximately twice as long, twice as thick, of darker color and with many more septa in each direction upon the natural medium than upon the carnation agar, differences which would ordinarily be regarded as clearly of specific rank.

Alternaria Brassicæ (Berk.) Sacc., from collard.

This fungus made hyaline mycelium in cba and cba+sodium asparaginate; black mycelium in cba+sodium asparaginate+glucose and in cba+sodium asparaginate+starch, starch producing by far the most pronounced effect.

Digestion of the starch grains, somewhat in advance of the tips of the oncoming fungus threads, produced a clear zone surrounding each colony in the starch-bearing plates.

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Ascochyta Chrysanthemi Stevens.

This fungus was grown in the usual media with no significant effects, except that the fungus did not digest the starch grains afforded in the medium.

A deposit of great thickness around mycelial threads was made in the case of certain media and not in others, as has already been noted.[1]

In some instances culture at a high temperature occasioned this same response.

SUMMARY OF CHEMICAL RELATIONS.

The most striking response to chemicals is in color, which so far as observed was invariably heightened by the presence of chemicals bearing carbon in available form, the form of available carbon varying for different fungi. Some fungi, possessing ability to digest starch, can utilize this as a source, while to others the carbon of starch is inaccessible. Special unknown chemicals in apple add vivid colors to fungi otherwise hyaline. Some chemicals also promote or inhibit spore formation. Some inhibit or promote growth of setae, and some even alter the size, color and septation of spores. Milburn, working under Klebs (Milburn, lc.), has also noted pronounced effects of chemicals upon the color of fungi. The difference in color effects produced by different fungi under the same conditions and with the same fungus under different conditions is also noted by Bessey.[2]

No correlation is noted between rapidity of lineal growth and nutritive value of the medium. In many instances most rapid lineal growth occurred in what was surely the poorest medium. Very poor media suffice in many cases also for spore formation, while rich media often result in cessation of spore formation.

Colletotrichum Lindemuthianum, sometimes with setae, often without, has long been of questionable generic position. The same is true of several other species of this genus. *Alternaria Brassicæ* and *Macrosporium Brassicæ* agree closely except as to presence or absence of catenulate spores.[3]

Variation of this kind is probably due to variation in chemical composition of the supporting medium, *e. g.*, change in sugar content as ripening proceeds, acting in such way as to give the fungus the appearance of belonging to one genus when upon the green sugar-free fruit, to another genus as the starch gives place to sugar as the fruit ripens.

IV. LIGHT RELATION.

The absence of material effect of light upon lineal growth with these species of fungi is shown in Table I.

---

[1] Bot. Gaz., 44, 1907, 241.
[2] Bessey, lc.
[3] *A. Brassicæ* Hyphae brevis conidia 60–80 x 14–18, septae 6–8.
M. Brassicæ Hyphae obsoletis conidia 50–60 x 12–14, septae 5–11.

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TABLE I.—*Relation of Light to Growth.*

Figures express growth in millimeters. The cultures marked "alternate" were kept several days in light and several days in dark; L=light, D=dark. Inoculated December 8, 1908.

DATE OF OBSERVATION.	CONDITION OF LIGHT.								
	On Macrosporium Brassicæ.			On Phyllosticta sp. indet.			On Ascochyta Chrysanthemi.		
	In Light.	In Alternate Light and Dark.	In Darkness.	In Light.	In Alternate Light and Dark.	In Darkness.	In Light.	In Alternate Light and Dark.	In Darkness.
December 9	Germ	Germ L	Germ	0	0 L	0	0	2 L	0
December 10	1	1 L	1	Germ	Germ L	Germ	Germ	3 L	6
December 12	6	6 L	6	4	4 L	4	4	12 L	12
December 13	9	10 L	9	7	7 L	6	12	16 L	14
December 14	13	12 D	11	10	10 D	7	15	20 D	18
December 15	16	15 D	15	13	13 D	10	17	25 D	22
December 16	17	17 D	17	14	13 D	13	25	30 D	25
December 17	23	23 L	21	16	16 L	16	33	37 L	31
December 18	26	26 L	29	20	18 L	19	39	39 L	37
December 19	28	28 L	29	23	20 L	20	41	45 L	37

Ascochyta Chrysanthemi Stevens. The growth is more floccose in darkness.

Phyllosticta sp. indet. This fungus forms its pycnidia in beautiful concentric rings when in open room, *i. e.*, alternate light and darkness, but in continuous darkness they were irregularly scattered. Culture No. 35 made concentric rings when in the light and failed to do so when moved to darkness. Cultures kept in the open room lay down rudiments of pycnidia mainly during the night, and it is probable that light exerts enough inhibiting influence on pycnidial development to give a growth predominance during the day and a fructifying predominance during the night.[1]

Alternaria Brassicæ (Berk.) Sacc. With this fungus the end of each day's growth, evening, marks the edge of a zone. The zone thus marked is intensified during the succeeding twenty-four hours by color changes. While zones are formed to some extent in continued darkness, they are more pronounced in the room condition.

SUMMARY OF LIGHT RELATION.

Light exerts little or no effect upon lineal growth with these fungi. It appears to exert an inhibiting influence on pycnidial development and in some instances is the cause of zonation in colonies.

V. UNKNOWN FACTORS.

Ascochyta Chrysanthemi Stevens.

This fungus frequently exhibited differences in character along different radii of the same colony, the conditions of medium, thickness of sowing, humidity, etc., being apparently identical. Fig. 12 shows such a colony. Along the radius *a*—*a* at *b* the colony bore pycnidia abundantly, and the mycelial

[1]Hedgecock, 1c.

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progeny of this strain extending to the periphery of the colony was rich in pycnidia, while most other radii of the colony were sterile or nearly so. Transfers were made from the point *c* (sterile) and *d* (pycnidial) to fresh plates. The sterile mycelium produced a colony which through its early days was sterile. As it aged it formed a few large pale pycnidia. The fertile strain produced a fertile colony with very numerous though small pycnidia. Transfers made again from these two strains resulted in a complete reversal of character, the fertile becoming sterile and the sterile becoming fertile. No explanation of this suggests itself.

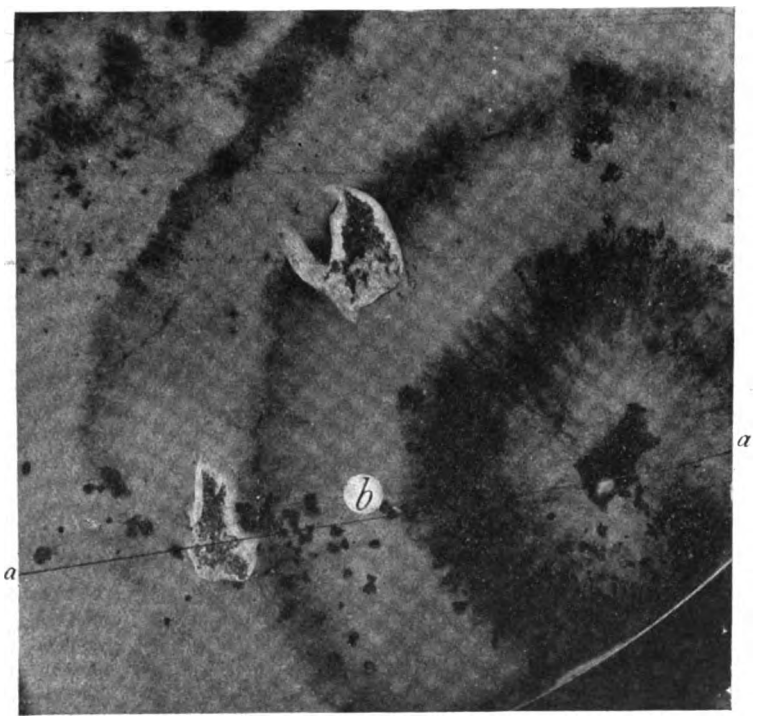

FIG. 12.—*Ascochyta Chrysanthemi* Stevens, showing abundant pycnidia on radius *a*–*a*, at point *b*, and paucity of pycnidia elsewhere.

When this fungus was plated from a suspension of spores two types of colony developed corresponding to the two strains mentioned above. The first "type of few pycnidia" developed a copious aerial mycelium of a loose floccose nature, extended regularly in all directions and was long devoid of pycnidia. When the pycnidia did form they were few, large and superficial (Fig. 13). The second "type of many pycnidia" had little or no aerial mycelium, all the mycelium being either immersed or of strict growth; was roughly circular in colony, not regularly so as in first type, and small, irregular, mostly immersed pycnidia were formed in myriads throughout the colony. (See Fig. 14.) These two types of colony appeared on the same plates which were in-

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oculated with spores from the same pycnidium, therefore developed in the same nutrient condition, humidity, temperature, etc. Depth of planting is not the cause of these differences, since flooding the plate with an extra tube

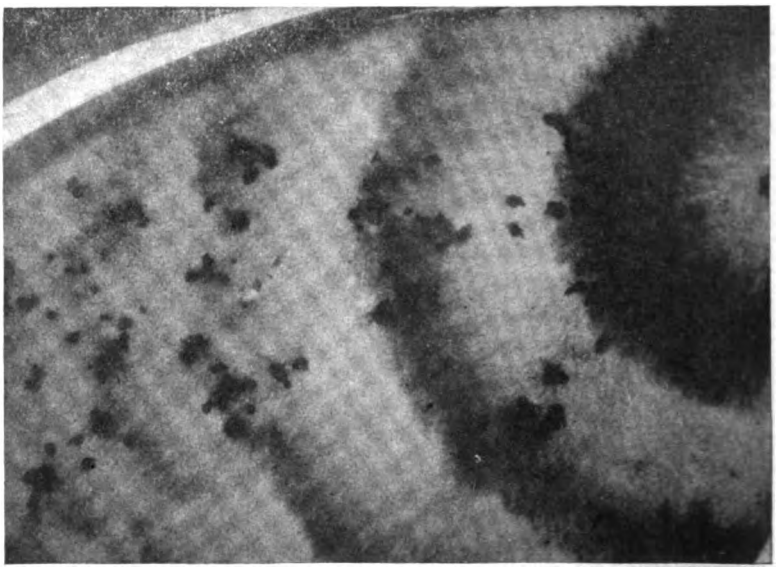

FIG. 13.—*Ascochyta Chrysanthemi* Stevens; portion of colony showing few pycnidia; cf. Fig. 14.

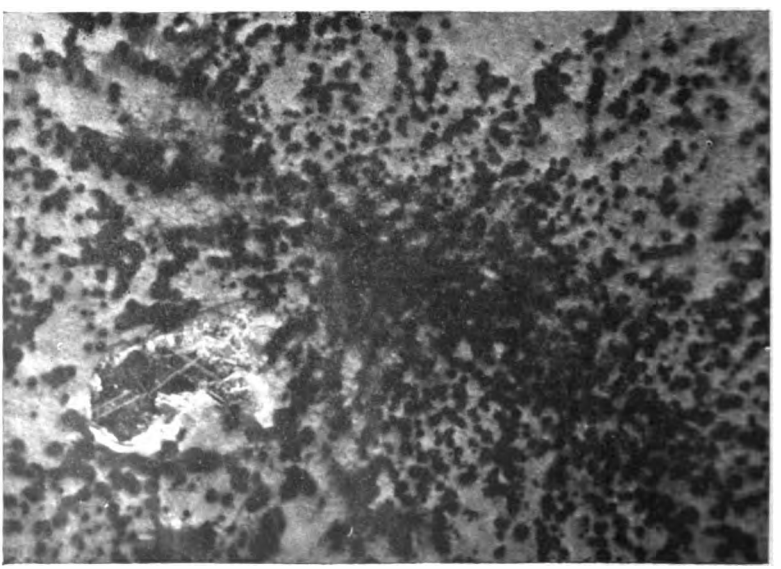

FIG. 14.—*Ascochyta Chrysanthemi* Stevens; portion of colony showing many pycnidia; cf. Fig. 13.

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of agar after the agar first plated had set, did not change the proportion of the two types. Nor did sowing in such way that the spores were at the bottom rather than at the top of the agar change results. There was a marked tendency of colonies of both types of the fungus to become more productive of large pycnidia where two different colonies approach each other, suggesting that there might be needed a co-operation of two diverse strains in order to form a pycnidium; that the strains of few pycnidia lacked the requisite individuals, and that the strains of many pycnidia had more than one individual to the colony. To test this, colonies were traced from the earliest development, resulting in clear evidence that in some instances a colony developed from a single spore was one with few pycnidia; in other instances a single spore produced a colony of many pycnidia.

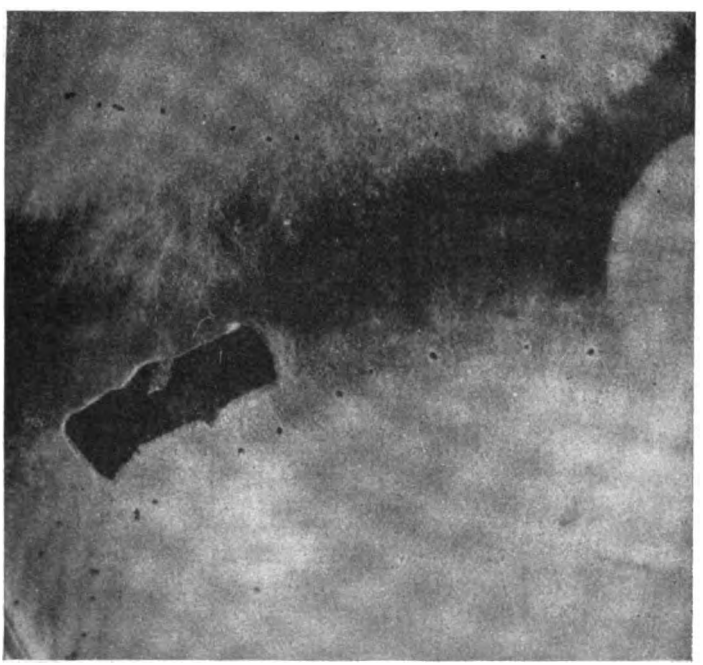

FIG. 15.—*Coniothyrium Fuckelii* Sacc.; portions of two colonies showing circles of pycnidia near margins.

Coniothyrium Fuckelii Sacc., from apple.

In one instance this fungus, which rarely fruited, made pycnidia in almost perfect circles near the margins of each colony on the plate. (See Fig. 15.)

These variations are inexplicable and remind one of the mysterious change from ascigerous to non-ascigerous condition so frequently met in life-history work with the imperfect fungi.

VARIABILITY IN SPORE MEASUREMENT.

Since the beginning of mycology it has been customary to give spore measurements in specific description, probably originally with the idea of

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giving some information as to the approximate size of the plant concerned rather than to give exact descriptive limitations. With the advance of time, great importance has come to be attached to spore measurements—greater, perhaps, than is warranted—and many species are now founded upon divergence in this one character, and often upon slight divergence.

To ascertain the variability in spore measurement under constant conditions and its variability as occasioned by change in environment, studies with several species of fungi were undertaken.

The measurements were all made in water in which the spores had stood long enough to become fully turgid, taking only such spores as were completely ripe, as was shown by the fact that they were extruded from the pycnidium, ascus, or sporodochium, naturally, without assistance. An eye-piece micrometer was used and the units here employed are usually one division of the eye-piece scale,[1] which constituted in most cases as small a unit as could be used to advantage. Spore measurements involving half the division were recorded as with the next lower interval. To avoid any possibility of unconscious selection, the spore lying closest to contact with the end of the micrometer scale at the completion of a measurement was taken for the next measurement.

In the polygons each small square (one 256th of a square inch) represents one spore.

We wish to acknowledge our indebtedness to Dr. G. H. Shull, who has kindly read this portion of the manuscript, for calculating the constants; to Mr. B. B. Higgins, by whom most of the measurements were made and upon whose very accurate and painstaking work the value of the measurements depends.

Ascochyta Chrysanthemi Stevens.

A. *Spores from the large pycnidium type* (see page 59).

Pycnidium No. 1. A large pycnidium produced in a colony which had very few pycnidia.

$$M = 4.9645 \pm 0.0393$$
$$\sigma = .9787 \pm 0.0278$$
$$C.\ V. = 19.714 \pm 0.581$$
$$n = 284$$

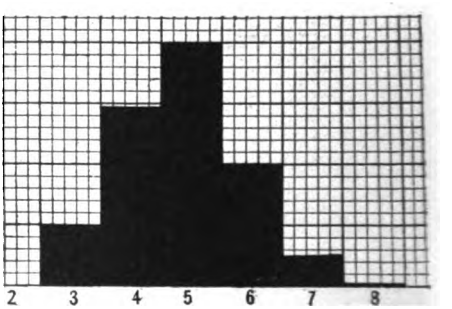

Fig. 16.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 1, large type. 3 should cover 20 squares instead of 25.

[1]Division equal 3.7 μ.

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Pycnidium No. 2. Large type.

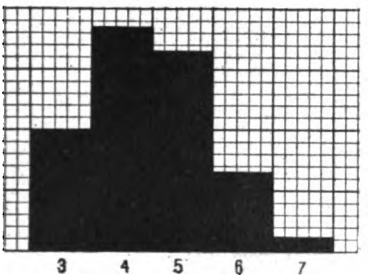

FIG. 17.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 2, large type.

M= 4.4318 ± 0.0398
σ= .9589 ± 0.0281
C. V.=21.638 ± 0.650
n=254

Pycnidium No. 3. From a plate bearing one large colony. The whole colony was characteristically one of few pycnidia which were of large type and light color. The spores were obtained without any possibility of the pycnidium being torn, that is, they were normally ripe spores.

M= 3.3848 ± 0.0245
σ= .6714 ± 0.0173
C. V.=19.836 ± 0.531
n=343

It is seen that these three separate pycnidia of the same type gave modes of 4.9645 ± 0.0393, 4.4318 ± 0.0398, and 3.3848 ± 0.0245; or, expressed in terms of the systematist, that in the three pycnidia the spores measured 11.1-29.6μ, mostly 18.5μ; 11.1-25.9μ, mostly 14.8μ; 7.4-22.2 μ, mostly 11.1 μ; showing that measurements from one pycnidium alone are not sufficient for reliable characterization.

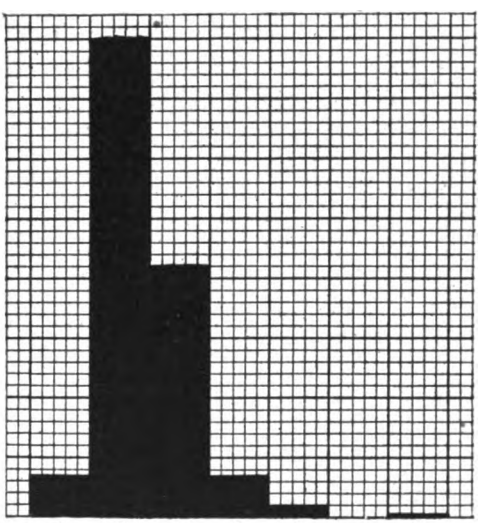

FIG. 18.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 3, large type.

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B. *Spores from small pycnidium type* (Fig. 14).

Pycnidium No. 4. Small type.

$M = 3.6011 \pm 0.0363$
$\sigma = .7183 \pm 0.0256$
C. V. $= 19.947 \pm 0.740$
$n = 178$

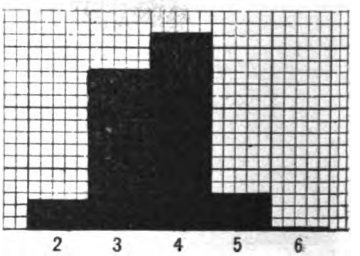

FIG. 19.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 4, small type.

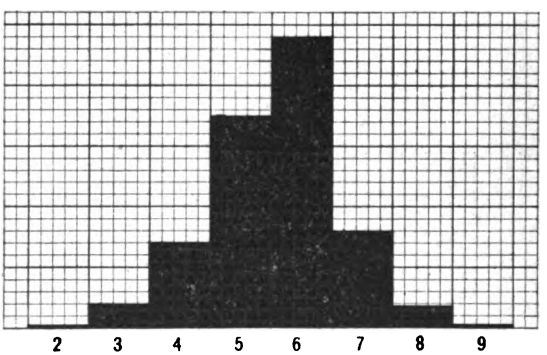

FIG. 20.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 5, small type.

Pycnidium No. 5.

Spores taken from small pycnidium colony shown in Fig. 14.

$M = 5.5850 \pm 0.0414$
$\sigma = 1.0737 \pm 0.0293$
C. V. $= 19.225 \pm 0.543$
$n = 306$

Pycnidium No. 6. A very small pycnidial type.

$M = 5.3629 \pm 0.0544$
$\sigma = 1.2711 \pm 0.0385$
C. V. $= 23.702 \pm 0.756$
$n = 248$

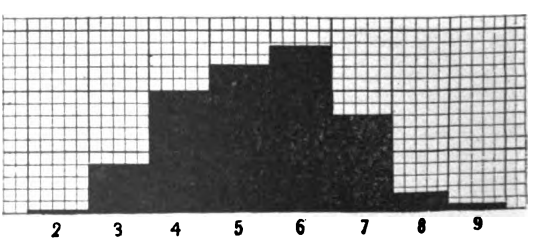

FIG. 21.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 6.

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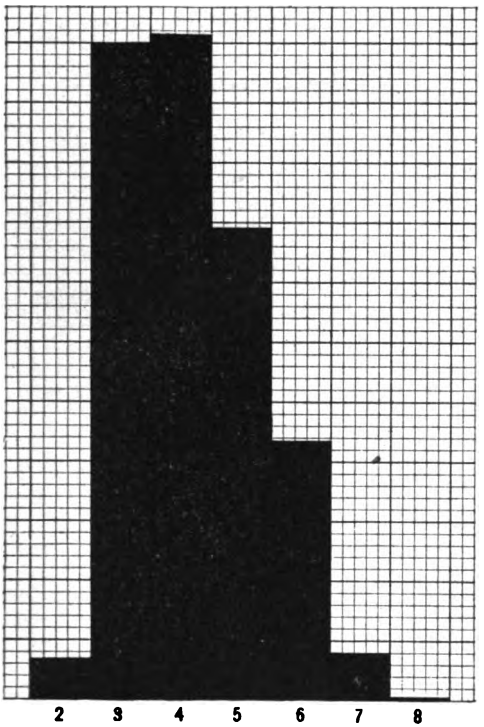

FIG. 22.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores of large pycnidia.

Collecting the data from the large pycnidium type in one polygon, and similarly with the small pycnidium type, we have:

$M = 4.1935 \pm 0.0247$
$\sigma = 1.0902 \pm 0.0174$
C. V.$=25.998 \pm 0.443$
$n=889$

$M = 5.0379 \pm 0.0335$
$\sigma = 1.3492 \pm 0.0237$
C. V.$=26.781 \pm 0.503$
$n=738$

It is seen that there is a tendency throughout for the smaller pycnidia to produce larger spores than are produced by the large pycnidia.

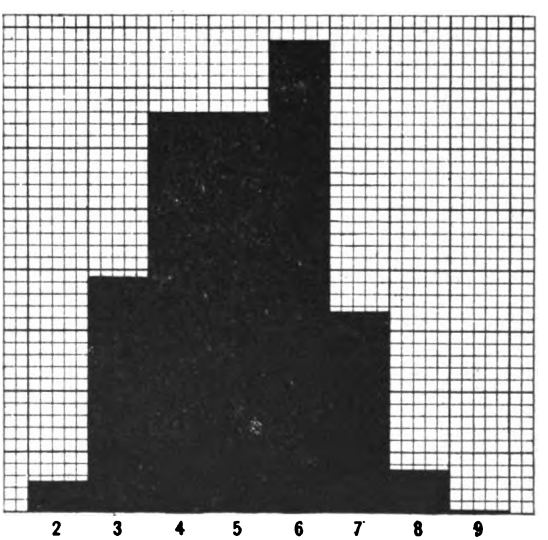

FIG. 23.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores of small pycnidia.

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C. *Measurements of spores from different media.*

Pure agar. The pycnidia on this plate were very scant, although they were normal in appearance and size.

$$M = 2.6241 \pm 0.0313$$
$$\sigma = .5354 \pm 0.0221$$
$$C.\ V. = 20.402 \pm 0.878$$
$$n = 135$$

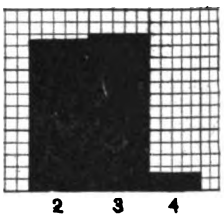

FIG. 24.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pure agar.

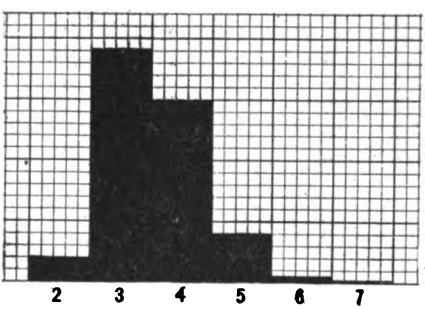

FIG. 25.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from cba + 0.25 per cent sodium asparaginate.

Cba+0.25 per cent sodium asparaginate.

$$M = 3.5637 \pm 0.0358$$
$$\sigma = 0.7579 \pm 0.0253$$
$$C.\ V. = 21.267 \pm 0.725$$
$$n = 204$$

$$M = 5.4267 \pm 0.0356$$
$$\sigma = .7896 \pm 0.0251$$
$$C.\ V. = 14.551 \pm 0.459$$
$$n = 225$$

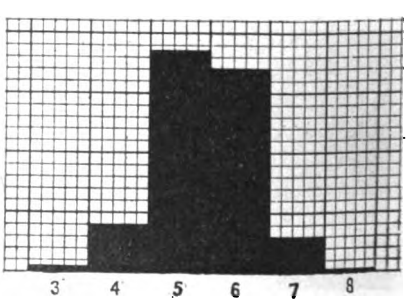

FIG. 26.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from cba+sodium asparaginate+starch.

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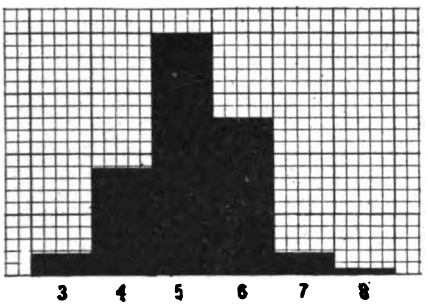

FIG. 27.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from cba+sodium asparaginate+glucose.

Cba + 1 per cent glucose. This was a remarkable colony with spores distinctly smoky or olivaceous.

$M = 5.1422 \pm 0.0408$
$\sigma = .9214 \pm 0.0289$
C. V. $= 17.919 \pm 0.579$
$n = 232$

Plated thickly in 4 per cent pea agar.

$M = 4.3246 \pm 0.0392$
$\sigma = 1.0138 \pm 0.0277$
C. V. $= 23.442 \pm 0.674$
$n = 350$

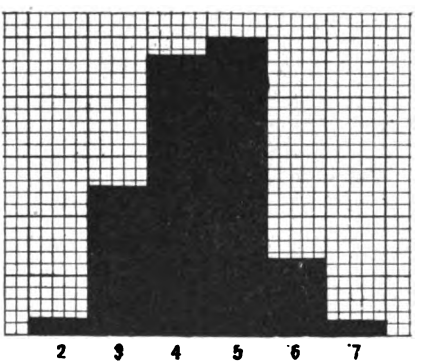

FIG. 28.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from 4 per cent pea agar.

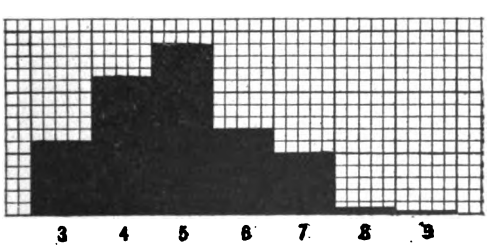

FIG. 29.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from cowpea agar.

Cowpea agar.

$M = 4.8657 \pm 0.0545$
$\sigma = 1.1885 \pm 0.0386$
C. V. $= 24.427 \pm 0.839$
$n = 214$

It is seen that on these different media the mode varies materially, being low on pure agar, higher on cba+sodium asparaginate, and still higher when glucose or starch is added. The mode is high also in natural media, such as pea agar and cowpea agar.

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In the terms of the systematist, spores from pure agar measured 7.4-14.8 μ, mostly 11.1μ; those from cba+sodium asparaginate 7.4-25.9μ, mostly 12.9μ.

SEPTORIA LYCOPERSICI SPEG. OF TOMATO.

Grown on apple agar.

$M=21.507 \pm 0.190$
$\sigma= 4.686 \pm 0.135$
C. V.$=21.787 \pm 0.655$
$n=278$

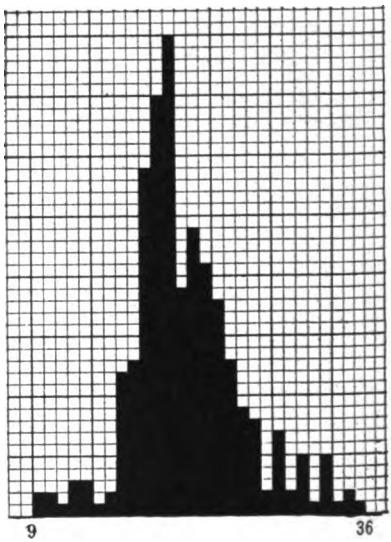

FIG. 30.—*Septoria Lycopersici* Speg. Polygon of spores on apple agar.

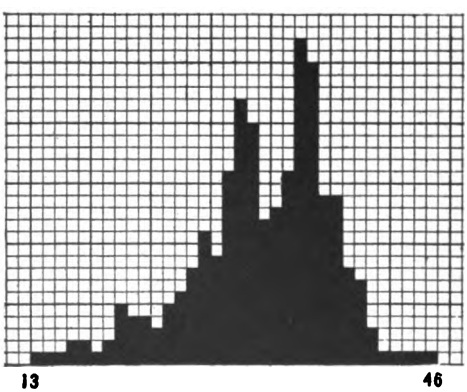

FIG. 31.—*Septoria Lycopersici* Speg. Polygon of spores on pure agar.

Grown on pure agar.

$M=31.675 \pm 0.242$
$\sigma= 5.879 \pm 0.171$
C. V.$=18.560 \pm 0.559$
$n=279$

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Although the number of spores measured in the two last instances is not large, the fact of a tendency to larger spores on the poorer medium, apple agar, is evident. The spores measured 33.6-133.2 μ, mostly 81.4 μ, those on pure agar 48.1-181.3 μ, mostly 133.2 μ.

Ascospores of Sclerotinia Libertiana Fuckel.

Spores were discharged spontaneously from the disk upon the cover glass, the disk being of middle age.

$M = 4.0880 \pm 0.0166$
$\sigma = 0.2930 \pm 0.0117$
C. V. $= 7.168 \pm 0.290$
$n = 142$

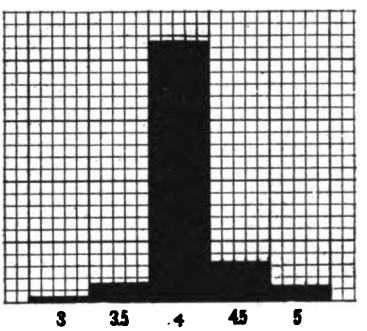

Fig. 32.—*Sclerotinia Libertiana* Fckl. Polygon of ascospores from middle-aged disk.

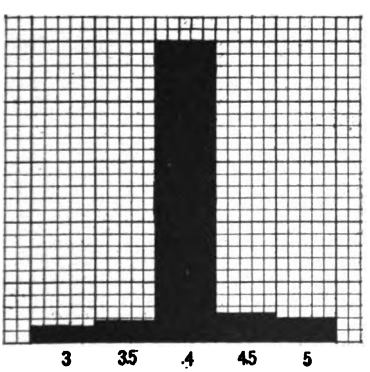

Fig. 33.—*Sclerotinia Libertiana* Fckl. Polygon of spores from young disk.

Spores were secured as in the last instance, but from very young disks.

$M = 4.0393 \pm 0.0214$
$\sigma = 0.3743 \pm 0.0151$
C. V. $= 9.267 \pm 0.380$
$n = 165$

No material difference in the size of the spores here appeared with the change in age of the disks.

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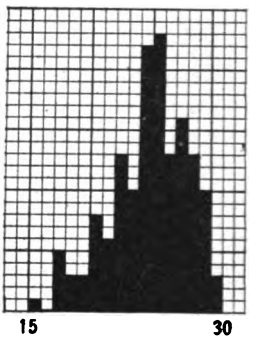

FIG. 34.—*Diplodia macrospora* Earle. Polygon of spores isolated from corn and grown upon pea agar; measurements showing length.

DIPLODIA MACROSPORA EARLE.

Spores of this species, isolated from corn, were grown upon pea agar.

$$M=24.362\pm0.176$$
$$\sigma=3.179\pm0.124$$
$$C.\ V.=13.050\pm0.519$$
$$n=149$$

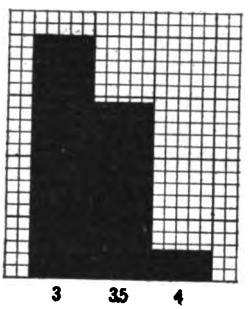

FIG. 35.—*Diplodia macrospora* Earle. Polygon of spores isolated from corn and grown upon pea agar; measurements showing thickness.

$$M=3.2595\pm0.0136$$
$$\sigma=.2727\pm0.0096$$
$$C.\ V.=8.367\pm0.297$$
$$n=183$$

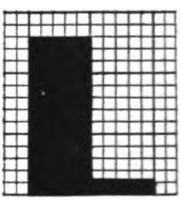

FIG. 36.—*Volutella fructi* S. and H. Polygon of spores showing width.

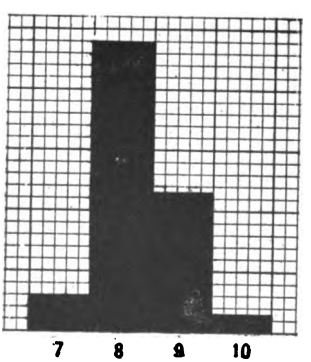

FIG. 37.—*Volutella fructi* S. and H. Polygon of spores showing length.

VOLUTELLA FRUCTI S. AND H.

$$M=8.27\pm0.0276$$
$$\sigma=.5778\pm0.0195$$
$$C.\ V.=6.986\pm0.237$$
$$n=200$$

The last five polygons are without particular significance and serve only to show the variation encountered in these forms.

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General Considerations.

The bearing of these facts upon mycological taxonomy is apparent. If a fungus can be easily changed as regards its essential descriptive characters by a change in substratum, density of infection or other environmental factor, these characters are worthless for descriptive purposes, unless the conditions under which they develop be accurately known.

There are two fundamental requisites of benefits from description: (1) to enable recognition of a particular form; (2) to aid in classification.

The first of these is necessary preliminary to the second, and it is with mere recognition that we have in many instances yet to deal in mycology, particularly among the group *Fungi imperfecti* with its enormous genera, such as *Septoria* and *Phyllosticta* and *Cercospora* with their thousands of so-called species. While life-history work and infection experiments will do much, accurate recognition of the form in hand is a necessary preliminary even to this.

To reach any satisfactory basis, many fungi must be studied in culture much after the fashion that bacteria are now studied.

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CARNATION ALTERNARIOSE.[1]

By F. L. Stevens and J. G. Hall.

To a leaf and stem disease of the cultivated carnation, *Dianthus Caryophyllus* L., our attention was called by local florists as causing serious damage. The disease, upon examination, proved to be one hitherto undescribed, and a laboratory study of it was undertaken.[2]

SYMPTOMS.

The disease manifests itself as spots, mostly upon the leaves, sometimes upon the stems, especially at the nodes. These spots are strikingly characteristic, of ashen whiteness, with the center occupied by an often scanty, though sometimes profuse black fungous growth. The diseased spot is dry, somewhat shrunken, thinner than healthy portions of the leaf, approximately circular, though often somewhat elongated in the direction of the longitudinal axis of the leaf. (Fig. 38.) When occurring at the node, the disease usually involves the bases of both of the leaves, as well as the stem between them. (Fig. 38, 2.) As these nodal spots age the disease penetrates through the stem, killing its tissue, which shrinks somewhat and becomes soft and disintegrated, resulting in death of the more distal portions of the plant.

VARIETY OF CARNATIONS AFFECTED.

A striking feature of this disease is its tendency to infect to a large degree one variety of plant, the Mrs. Thomas W. Lawson, to the exemption of others. In all cases which have come to our notice it has been this variety solely which was diseased; moreover, the only records that we find of the disease imply the same susceptibility.[3]

CAUSAL FUNGUS.

Throughout the diseased tissue of all spots occurs in great abundance a characteristic, dark, branching, septate mycelium (Fig. 40, 3). The surfaces of diseased spots in periods later than their earliest youth present an abundance of black cespitose hyphæ arising from the stomata (Fig. 40, 4). Spores of the Alternaria type are found in abundance, Figs. 40 (5) and 40 (6), both *in situ* upon these hyphæ, and strewn over the surface of the diseased spots between the hyphal bases. The character and arrangement of the hyphæ is shown in Figs. 40 (7) and 40 (8). This fungus was constantly associated with the disease, and no other fungus was found. The presumptive evidence was therefore very strong that this fungus was the cause of the disease. In view of the often saprophytic habit of Alternaria, conclusions on this point would not be valid without evidence from inoculations.

[1]Printed in the Botanical Gazette, 47, No. 5, May, 1909.

[2]Through the kindness of Dr. Orton, U. S. Department of Agriculture, we learn that a *Macrosporium* disease of carnation was reported from Strassburg, Pa., in 1906, and one attributed to *Alternaria* from Connecticut by Clinton in the same year.

[3]Orton, Year-book U. S. Dept. Agr., 1905, p. 611.

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FIG. 38.—(1) Single leaf showing diseased spot near base. (2) Diseased plant showing removal of lower leaves by the gardener in his efforts to stop the progress of the disease.

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INOCULATIONS.

The fungus was easily isolated by direct transfer of spores from the diseased spots to carnation leaf agar plates.

On October 27 numerous inoculations were made upon two plants under bell jars, using small pieces of agar, bearing spores and mycelium. One of the plants was left uninjured and the inoculum was placed in the axils of the leaves; in the majority of these cases the inoculations resulted in infection. The other plant was injured by the prick of a needle at the point

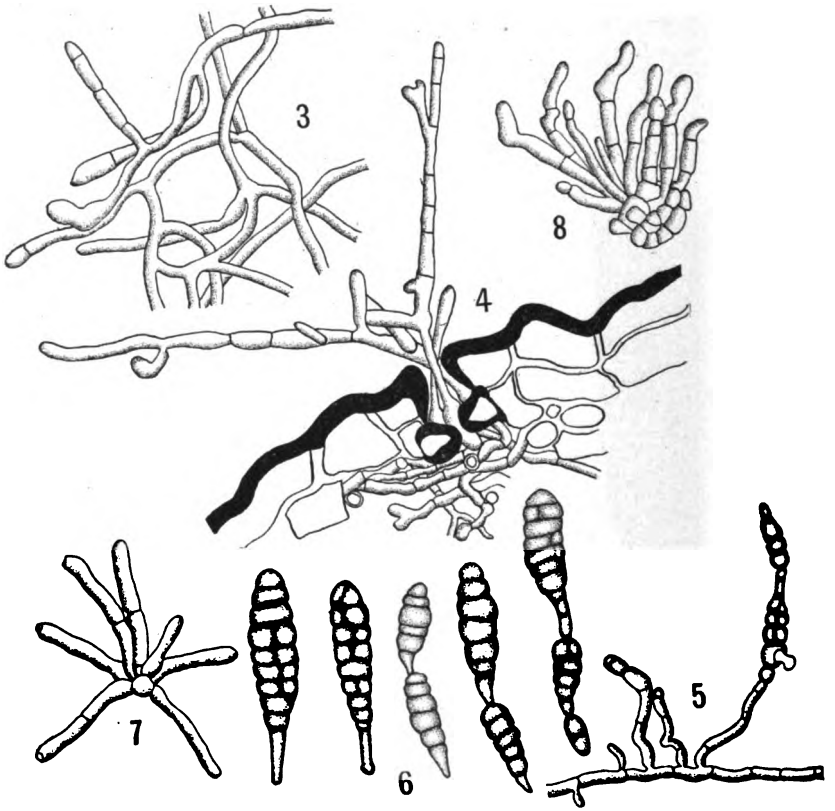

FIG. 40.—(3) Mycelium showing branching and septation. (4) Showing mycelium below stoma and hyphæ emerging through the stoma. (5) Showing catenulate spores as borne upon hyphæ. (6) Spores showing shape, septation and catenulation. (7) A young cluster of hyphæ. (8) An older cluster of hyphæ.

of inoculation. In these cases about two-thirds of the inoculations were successful. Inoculations with spore suspension were also made upon five branches each, of two other plants, and each was covered by a large test tube plugged around the stem with cotton to preserve a humid atmosphere. As in the former cases, the inoculations on one plant were at injured points and those on the other plant were at uninjured points. The results from these spore inoculations were the same as in the cases of inoculations with agar blocks. When these inoculations were made, others were made upon six other plants

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from the same spore suspension, but the plants were not covered or injured in any way. Following these last inoculations no signs of the disease were seen. It seems from these experiments that the injured plant is readily susceptible to infection, as is also the uninjured plant if kept in humid condition, but that the uninjured plant in a relatively dry atmosphere is difficult or impossible of infection. In case of successful inoculation the diseased spots were well developed at the end of a week. The removal of the protecting bell jar from plants already infected resulted, usually, in cessation of development of the spot. These facts agree well with the field observation that the most damaging infection occurs at the leaf axils, points well adapted to collect and hold water, thus providing conditions for optimum development of the fungus.

CULTURE CHARACTERS.

The fungus was grown upon many different media. Its characters upon these media have been noted elsewhere.[3] The most important culture characters may be summarized as follows:

Upon media poor in available carbohydrates the mycelium was nearly hyaline and the hyphæ and spores pale; upon media rich in carbohydrates mycelium, hyphæ and spore were very dark. Upon the natural medium the spores were more regular and uniform in shape and were much larger than upon artificial media.

SPECIES OF THE FUNGUS.

Of the Alternarias there seems to be only one, *A. longispora* McAlph, growing upon members of the pink family (*Caryophyllacea*), (Sacc. Syll. Fung., 18:638), and the description of this does not agree with ours in size, shape, or septation of its spores.

Therefore, unless an attempt be made to identify this form with some one of the seven or more species of Macrosporium infecting the pink family—a procedure which would be unjustifiable without resort to cross-culture inoculations and extensive study in artificial media—this form had best be designated as a distinct species, for which we propose the following name and description:

Alternaria Dianthi n. sp.

Hyphæ cespitose from stomata, amphigenous, dark brown, 1-4 septate, ascending, 1-25 from each stoma; conidia 26-123 x 10-20 μ catenulate, clavate, tapering to pedicul, base obtuse, dark brown, transverse septa 5-9, longitudinal septa 0-5.

Spot ashen white definite, subcircular.

On artificial media poor in carbohydrates color of mycelium and spores lighter, smaller and with fewer septa.

Habitat: Living leaves and stems of *Dianthus Caryophyllus*, Raleigh, N. C.

[3] Stevens and Hall, Variation in Fungi Due to Environment, Bot. Gaz. 48, July, 1909.

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HYPOCHNOSE OF POMACEOUS FRUITS.[1]

By F. L. Stevens and J. G. Hall.

A disease which from its most prominent symptoms may popularly well be called the *leaf blight* and which may technically be designated as *Hypochnose*, has been under observation and study by the authors several years, as affecting the apple, pear, and quince. During this time it has been frequently referred to the Experiment Station for diagnosis and treatment, and it seems to be one of the worst diseases occurring on neglected trees in the humid portions of the State.

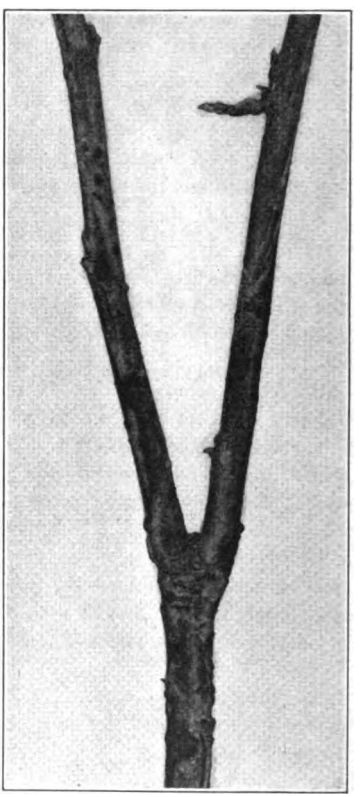

Fig. 41.—Sclerotia and rhizomorphic mycelium upon apple twigs; natural size.

SYMPTOMS.

Viewed from some distance, trees in early stages of *Hypochnose* appear much as do trees affected with the ordinary fire blight (*Bacillose*) caused by *Bacillus amylovorus* (Burrill) De Toni, that is, the leaves on numerous

[1]Printed in Annales Mycologici, Vol. 7, No. 1, 1909.

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twigs throughout the trees are dead. Differing from *Bacillose*, however, the leaves instead of standing erect, usually droop, hanging down in dense, matted masses. The affection, too, is limited to the leaves, the twigs themselves not dying as in the case of *Bacillosc*. The resemblance is very striking, and to the casual observer *Hypochnosc* would doubtless pass for the widespread, well-known "fire blight."

In later stages of the disease most of the affected leaves fall away and the similarity to *Bacillose* disappears, the tree now attracting attention chiefly by its scant equipment of leaves. Closer inspection of the twigs with the affected leaves shows each of them to bear two characteristic structures:

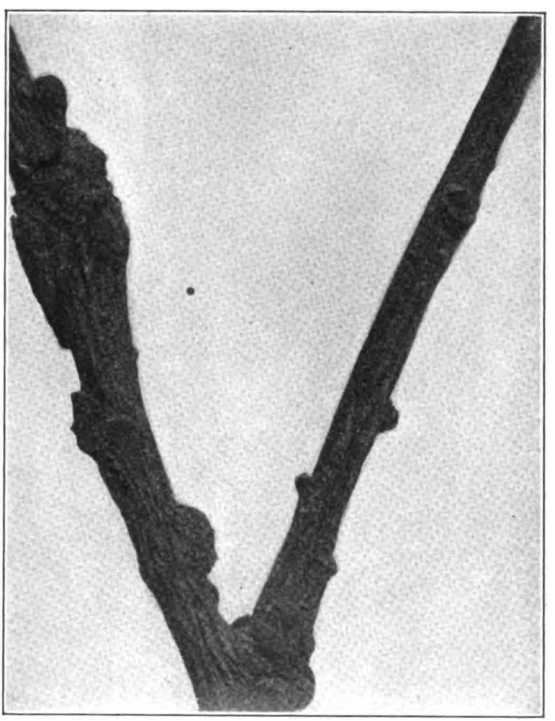

FIG. 42.—Sclerotia on apple twigs, enlarged.

1. Roundish or oblong sclerotia, usually 3 or 4 mm. in diameter, which are clearly shown on the left-hand branch in Fig. 41, and somewhat enlarged in Fig. 42.

2. Mycelial ribbons, rhizomorphic structures extending lengthwise of the twigs and petioles. (Fig. 43.)

The sclerotia originate as white masses of interwoven mycelium, which when mature become rich chestnut brown in color. They are formed in great abundance upon the twigs of the current year, especially upon the lower, shaded, damp side, but very sparingly or not at all upon the petioles

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or leaves. On two-year-old twigs the sclerotia are darker in color, shriveled and sometimes cracked, and it is doubtful if they live longer than through the summer following their origin. Upon badly affected trees it is possible to find sclerotia upon older twigs, two, three, four, or five years old, the size of the sclerotia being diminished by waste, shrinking, and weathering, with the age of the wood upon which they rest. Sclerotia are sometimes found upon fruit, though much less frequently than upon twigs.

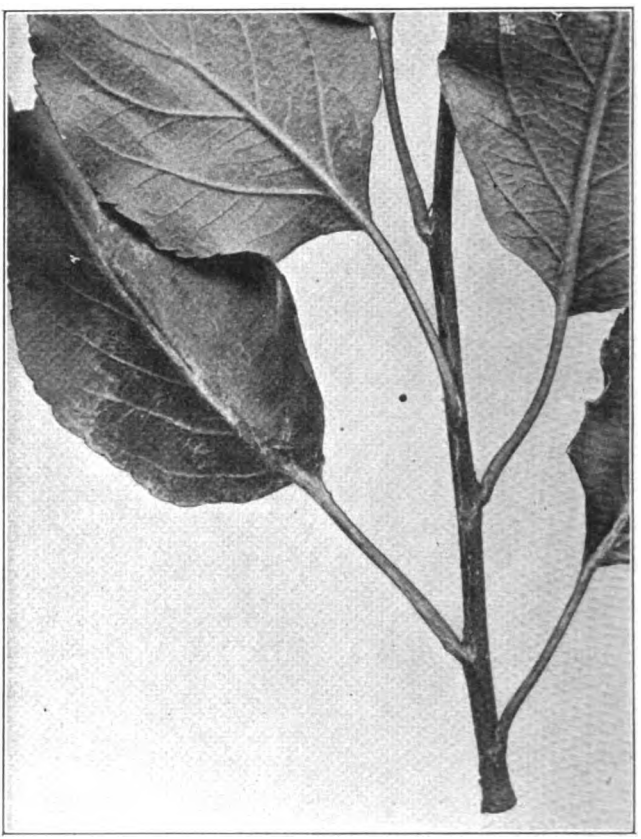

FIG. 43.—Rhizomorphic mycelium upon apple twigs and petioles; weft of floccose mycelium on inferior surface of leaf.

The mycelial rhizomorphic structures when young are white, but as they age they rapidly assume a characteristic glistening brown appearance. They extend in a general longitudinal direction, and usually remain unbranched between the nodes, though they sometimes branch and anastomose, forming a small plexus. Occasionally branches diverge to courses leading around the twig. At the base of each small twig the ribbon usually branches, a portion of it passing onto the smaller twig.

Branches of these mycelial ribbons also follow up the petioles and the main veins of the leaves, eventually spreading out, separating into single

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mycelial threads and becoming lost to the naked eye. The mycelial ribbons on the older wood die and often weather away, though they adhere with considerable persistence.

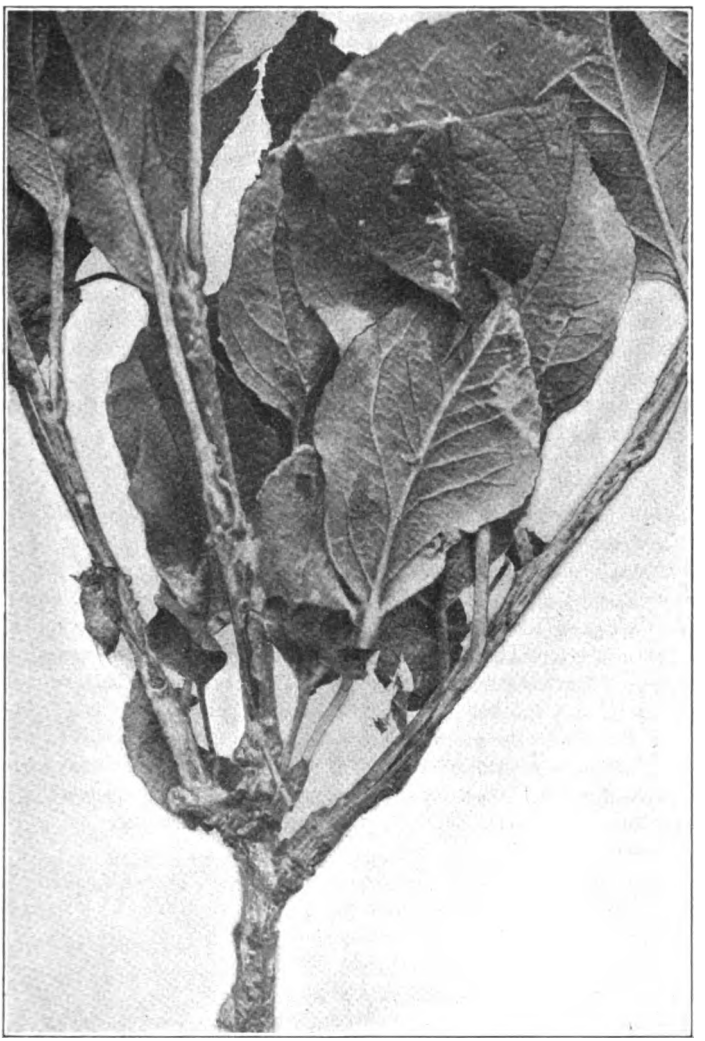

FIG. 44.—Apple twig showing characteristic matting of dead leaves held together by dense growth of mycelium; twigs and leaves densely covered by mycelium and sclerotia.

Upon the under surface of affected leaves may be found usually a more or less dense reticulum of mycelial threads. In some instances this weft consists of a dense mat of threads, white or fuscous according to their age (Fig. 43, lower left-hand leaf), in other cases the network may be so sparse as to be imperceptible to the naked eye.

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In all cases there is organic connection between this network on the leaf and the mycelial ribbons traversing the petiole. These ribbons are seen under the microscope to fray out and become dissipated over the under leaf surface.

The organic connection between the reticulum on the leaves, the mycelial rhizomorphic strands, and the sclerotia is established clearly and beyond doubt.

In some cases, comparatively rare, the weft on the lower surface of the leaf takes on more even texture, different from the tangled heaps more often found. In this condition the weft can be stripped from the leaf like a false epidermis. This is the sporogenous part of the fungus.

The twigs bearing the fungus do not die from its presence. They seem to be injured only indirectly through the effect of the fungus upon the leaves.

Leaves bearing the fungus turn brown and die. Since they droop in dying, they thus often come in contact with other leaves and the fungus is afforded a ready means of migration to the new victim, which in turn rapidly succumbs. If humid conditions prevail, the fungus grows with great rapidity and vigor between the matted masses of leaves, thus resulting in fastening the dead leaves somewhat firmly together and furnishing one of the distinguishing characteristics of the disease. (Fig. 44.)

FUNGUS.

The mycelial ribbons, which may be termed the *migratory mycelium*, to distinguish it from the vegetative and fructifying mycelium, consist of more or less parallel mycelial threads very uniform in diameter, about 5.8 μ, comparatively thick, walled and rigid, of characteristic glistening, smooth surface, white when young, tawny or buff when old, and nearly or quite devoid of protoplasmic contents. These threads are septate at intervals of about 40-120 μ, and branch rather infrequently. The branches originate usually at right angles to this mother strand, but almost immediately bend to assume a direction parallel to the main ribbon. No clamp connections were seen.

A section of the sclerotia reveals them as compactly woven masses of swollen irregular hyphæ. They are entirely devoid of any special epidermal structure, false epidermis, or rind, the peripheral structure being identical with that of the interior.

The sporogenous reticulum is of very close, irregular mesh of hyphæ of varying thickness, readily distinguished from the migratory mycelium, a single thread of which is occasionally seen across the field, by its thinner wall, greater irregularity of shape and size, and by its richness of protoplasmic content. Arising from the hyphæ of this reticulum are numerous thickened swollen branches which prove to be the basidia, bearing four slender sterigmata which bear the four spores. (Fig. 45.)

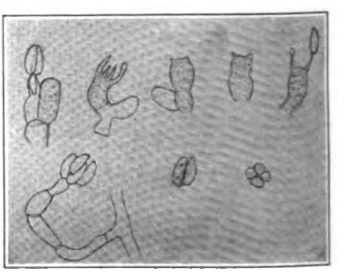

FIG. 45.—Basidia, sterigmata and spores.

The spores are oblong, slightly flattened on the side adjacent to the companion spore and taper slightly at each end. They are very uniform in size,

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4.7 - 5.8 x 10.5 - 11.6 μ. Of thirty-eight spores measured, thirty were of the larger dimension given and eight of the smaller dimension.

When stored in humid atmosphere, as in a culture dish, for a day or so, the fungus grows luxuriantly, producing great quantities of cotton-like mycelium. (Fig. 44.) The fungus was seen to spread 1 cm. in every direction from the point of contact in two and one-half days, when leaves bearing the fungus in this vigorous vegetative condition were placed in contact with healthy leaves in the moist chamber. Specimens wrapped to mail, when wet from rain, produced voluminous growth in forty-eight hours, many leaves becoming matted together, others becoming completely covered with the cotton-like mycelium and fringed on the edge with a border of mycelium reaching out for more victims.

The development of the fungus in early spring has not been studied, but it is clear that the sclerotia are hibernating structures and that in spring they serve as the initial points for new invasion. The spread of the fungus from point to point is chiefly by means of the rhizomorphic structures, which serve the purpose so admirably that by midsummer the uppermost buds are reached and already overlaid by sclerotia ready to carry on the invasion again another season. The work of the sclerotia is so completely done that rarely, if ever, does the parasite allow the escape of any of the branches originating from a twig upon which the fungus has established itself. Unless saved by outside aid, to be once infected is to be always infected.

A beautiful adaptation is noted in that the formation of sclerotia is abandoned on leaves where they would be of but minor importance, perhaps of no use at all, and is carried to a maximum upon twigs, particularly the most distal ends of the twigs, where they are of maximum utility in the perpetuation of the species.

The perfection of vegetative methods of reproduction has lessened the value or necessity of spore formation, a fact which perhaps explains the comparative rarity of fructification in this fungus.

THE FUNGUS IN NORTH AMERICA.

While the spore-bearing structures of this fungus were not seen, and consequently its classification was not known in America until 1907,[1] its sclerotia and rhizomorphic structures have several times come to the attention of mycologists in the United States. Thus Atkinson writes us that he believes he had the same thing sent him when he was connected with the Alabama Station.

Burt writes in private letter that the sclerotia were known to him, but he did not receive the fructification. He also states that specimens of the sclerotial stage have been referred to him on living twigs of apple, and on pear twigs.

Farlow says that sterile parts of the fungus have several times been referred to him. The sterile parts of this fungus and the destructive effects of it were noted by Quaintance with photographs and with the statement[2] that the fungus is known in Florida and Georgia, and that in one case it constituted for several years the most destructive fungus in the orchard.

[1] STEVENS, Two Interesting Apple Fungi, Science, n. s. 27, p. 724.
[2] Ga. Sta., 13th Rpt., 1901, p. 359.

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Earle states in private communication that the fungus was sent to the Alabama Station several times from Florida and Georgia while he was connected with it.

What was probably the same fungus was also mentioned by Sheldon as occurring upon apple, pear, and plum twigs, and by hearsay upon currant, gooseberry, and cherry in West Virginia.[3]

Collections in North Carolina have been made on the apple at Horseshoe, Addie, Franklin, Hayesville, Marshall, Murphy, Robbinsville, Sylva, Bryson City, Fatima, Newton, Eufola, Mount Airy, Spruce Pine, Rutherfordton, Chimney Rock; on the pear at Sylva, and on the quince at Horseshoe.

Collections of spore-bearing material were made at Mount Airy, Spruce Pine, and near Rutherfordton.

IDENTITY OF THE FUNGUS.

This fungus in all of its remarkable characters agrees with the description of *Hypochnus ochroleucus* Noack,[4] published by Noack as *Hypochnopsis*, a fungus which was found by Noack in the State of Minas Geraes, Brazil, on apple and quince trees, and which was supposed to be the cause of a diseased condition of the leaves. Noack says in part that the apple trees and quinces attacked by this fungus were brought to his attention by the dryness of many leaves. "Examined more closely, one sees fine, shining strands, white or ochre color, on the branches, often in spiral or elongated spiral lines. They approach the pedicels of the leaves, follow up the same, spread over and cover the lower side of the leaves with a very fine net of hyphæ. A few of these hyaline hyphæ end in corrolloid branches fastened strongly to the skin of the leaf and serve, doubtless, for the purpose of attaching the fungus to it. * * * The attacked leaves wilt and dry altogether, but they can remain on the trees a long time, adhering together in a confused mass, attached to the branches mainly by the tenacious threads of the mycelium. * * * Unfortunately, we are lacking its fructification, and for that reason its classification is doubtful. But we can find a very similar fungus belonging to the family of *Hypochnaceae* in the forest around Campinas, and therefore we call it provisionally our *Unknown Hypochnopsis*."

While it has been impossible to find specimens of Noack's fungus in any of the Brazilian or European herbaria, there seems to be no doubt of its identity with the form under discussion.

DISTRIBUTION.

This disease prevails generally throughout the mountain section of North Carolina; and that it is not limited to the mountains is shown by the fact that specimens have been sent to us from the coastal plain region with complaints of damage. (Fig. 46.) From the observations of Atkinson, Earle, Quaintance, and Sheldon, its presence is known in the mountains of West Virginia and in Alabama, while the observations of Farlow and Burt indicate its much more widespread existence.

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[3] W. Va. Sta. Rpt., 1905–06, p. 31.
[4] Saccardo, Sylloge Fungorum, 16, p. 197.
[5] Boletim do Instituto Agronomico do estado de Sao Paulo Em Campinas. 9, 1898. Marco Numero 1, Sao Paulo, Brazil.

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Our own observation, agreeing with those of Noack in Brazil, show the disease to occur with much greater destructiveness in humid localities, such as the mountain valleys where the dew is excessive and morning fogs prevail, and it seems probable that this disease is of wide distribution where these conditions obtain.

FIG. 46.—Map of North Carolina; shaded counties are those in which disease occurs.

PROPHYLAXIS.

The fungus, wintering in a purely superficial manner upon the twigs and depending to but a slight degree upon spores, will probably give way to thorough spring sprayings. The fact that the disease has not been noted upon sprayed orchards indicates the efficiency of such treatment.

PARASITISM OF HYPOCHNUS AND CORTICIUM.

These genera, which are difficult to separate and which by many are considered as identical, are in the main saprophytes, yet several cases of parasitism have been attributed to them. Among the parasitic forms Frank[6] in 1895 recognized only two as belonging to the genus *Hypochnus*, viz., *H. Solani* P. & D., noted on potatoes as early as 1891,[7] and *H. cucumeris* Frank,[8] which was noted as the cause of a cucumber disease in 1883 and later on lupine and clover. *H. filamentosus* Pat. has since been described as growing upon live leaves of *Caryophyllaceæ* and *Amaryllidaceæ* in Quito, and Eustace has recently discussed a species of *Hypochnus* as causing a decay of stored apples.[9]

H. Gardeniæ, Zimm., described by Zimmerman,[10] closely resembles the species in hand in the formation of ribbon-like strands on the twigs, which then extend to the lower sides of the leaves and develop a sporogenous layer; also in the structure of its fruiting portion.

H. Hellebori Rostr. is noted as a parasite upon *Helleborus niger* by Rostrup.[11]

H. fuciformis (Berk.) McAlp. grows parasitically upon Australian grasses in very destructive form.[12]

In the genus *Corticium* as parasites we find the following:

C. confluens Fries, noted by Jaczewski as a faculative parasite preying upon *Caragana*.[13]

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[6]Die Krankheiten der Pflanzen, 2, p. 219.
[7]Soc. Myc. Fr. 8, p. 221.
[8]Hedwigia 18, p. 127.
[9]N. Y. Sta. Bul. 235.
[10]Centbl. Bakt. II, 7, p. 102.
[11]Ztschr. Pflanzenkrank, 9, p. 47.
[12]Ann. Mycol., 4, p. 541. McAlpine, A New Hymenomycete.
[13]Ztschr. Pflanzenkrank, 10, p. 341.

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C. vagum B. & C. var. *solani*, which has been identified by Rolfe as the fruiting form of *Rhizoctonia*.[14]

C. javanicum (P. Henn.) Sacc. & Syd. on *Coffea*, *Thea*, *Bixa*, described as the cause of disease by Zimmerman.[15]

Associated with this fungus are sclerotia, probably genetically connected with it. Disease caused by the fungus upon a large number of other plants is mentioned by Zehntner.[16]

C. dendriticum P. Henn. is noted by Hennings[17] as a parasite on orange stems.

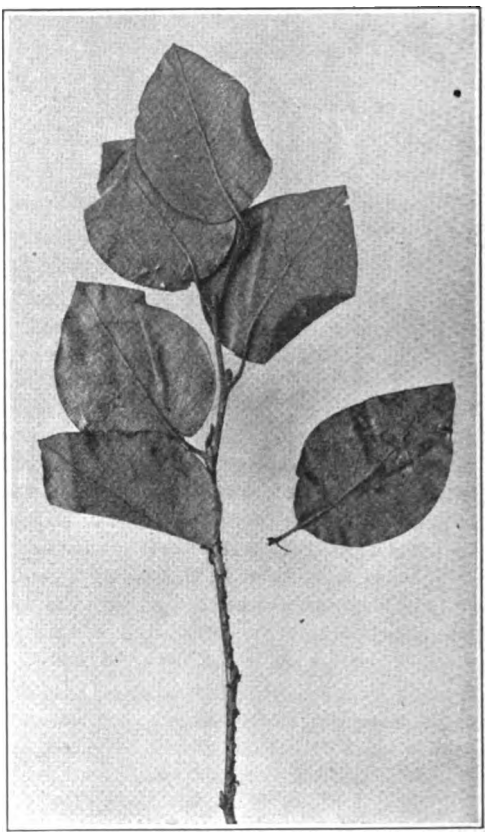

FIG. 47.—Quince branch and single leaf, showing sclerotia and mycelial masses.

ADDENDUM.

Since the preparation of the above article this fungus has come to our attention upon two new hosts, and collections on old hosts have been made in several new localities, as is indicated on next page.

[14]Col. Sta. Bul. 91.
[15]Centbl. Bakt. II, 7, p. 102.
[16]Ztschr. Pflanzenkrank, 18, p. 45.
[17]Centbl. Bakt. II, 9, p. 939.

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On Apple.

Robbinsville .....August 6, 1909.....F. L. Stevens.
Murphy .....August 9, 1909.....F. L. Stevens.
Hayesville .....August 10, 1909.....F. L. Stevens.
Eulalie .....August 14, 1909.....F. L. Stevens.
Leicester .....July 17, 1909.....B. B. Higgins.

On Quince. (Fig. 47.)

Eulalie .....August 14, 1909.....F. L. Stevens.

On Snowball (Vibernum).

Eulalie .....August 14, 1909.....F. L. Stevens.

On Lilac (Syringa vulgaris).

Eulalie .....August 14, 1909.....F. L. Stevens.

In many sections of Western North Carolina the fungus was so prevalent as to be found on nearly every tree seen, and whenever present the disease was always of extremely destructive character, resulting early in complete defoliation.

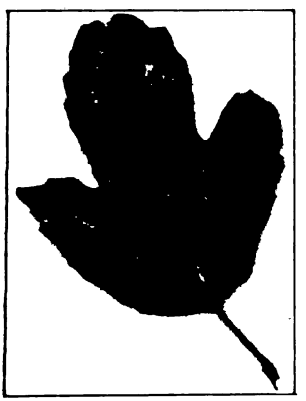

FIG. 48.—Leaf of Snowball showing white masses of mycelium.

The fungus on the Snowball (*Vibernum*):

Only one collection was made on this host (though what was supposed to be the same was glimpsed on other occasions), and then in a valley where the fungus grows with especial luxuriance upon its more usual hosts. The disease caused upon this host agrees in every particular with that upon the apple, except that as the leaf collapses under the attack of the fungus the mycelium accumulates in much more dense masses upon the under surface of the leaf. (Fig. 48.) This difference in habit may be due to the thinner texture of the leaf which allows it to fall into folds, thus producing regions of especial moisture and forming more vigorous growth of mycelium.

Fungus on Lilac (*Syringa vulgaris*):

Only one collection was made upon this host, and this in the same yard where the fungus was found upon apple, quince, and snowball. The characters of disease produced were almost identical with those upon the apple. No such development of loose mycelium appeared as upon the snowball, probably owing to the stiffness of the leaf.

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NEW FIG ANTHRACNOSE[1] (COLLETOTRICHOSE).

By F. L. Stevens and J. G. Hall.

A fig disease, the chief symptoms consisting of rotting and premature fall of the fruit, has come to our attention from the eastern part of North Carolina. The disease begins before the fruit commences to ripen, as small specks of rot on the fruit surface. Such rotten specks are usually very numerous, from five to thirty-five or more on each fig. The spots are soft, watery in appearance and definitely bordered. At their centers they are brownish and

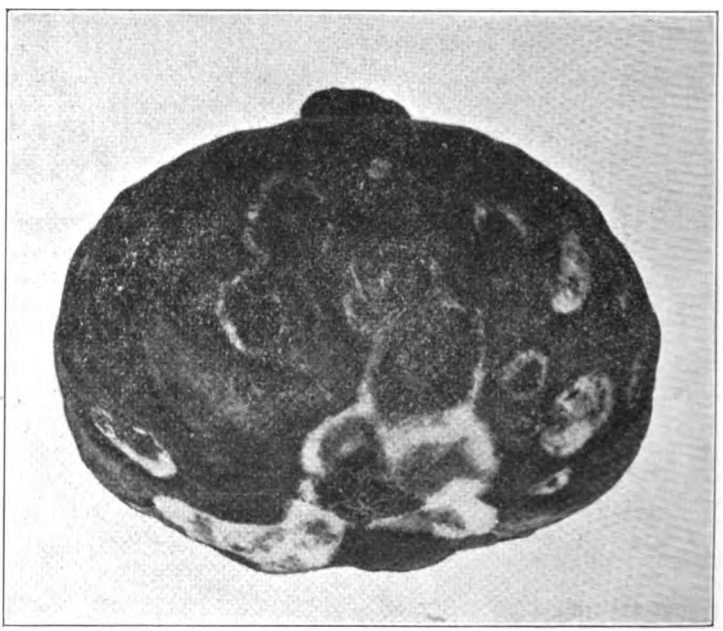

Fig. 49.—A single fig somewhat enlarged, showing white floccose mycelium around and over the spots.

slightly sunken. The spots enlarge rapidly and very soon the central region of each is occupied by numerous small, moist, pinkish to salmon colored pustules, each less than a millimeter in diameter.

The affected fig rapidly assumes a rotten appearance, loses its firmness, becomes watery, shrivels, and is soon almost entirely covered with the spore-bearing pustules. If under humid conditions, the spots become bordered and covered with a more or less dense growth of aërial, floccose, white hyphæ, which are sometimes so abundant as to produce a dense mat either over or surrounding the spot. This condition is shown in Fig. 49 somewhat enlarged.

[1]Presented at the December Meeting, 1908, of the A. A. A. S. Published in part in Zeitschrift f. Pflanzenkrankheiten 19, p. 65.

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In later stages of decay the fig is usually invaded by a large number of saprophytic fungi, usually predominated by dark green or black.

The fruit usually falls early in the decay. The disease prevails to such an extent that an affected bush may fail each year to mature its fruit, though setting fruit in abundance. The leaves of the affected bushes are also often diseased, turning brown, shriveling at the edges, and dying. The rot resembles that of the apple (*Glomerellose*) and the spots in a general way resemble the disease spots of the cotton anthracnose (*Colletotrichose*) or that of the bean or watermelon.

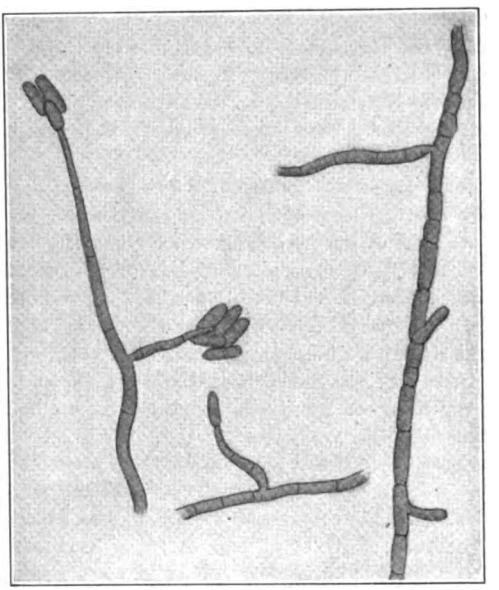

FIG. 50.—Showing mycelium, septation, branching and spores formation.

CAUSAL FUNGUS.

The diseased spots upon the fruit are always occupied by a species of *Colletotrichum*, which from the abundance of its spores seen *en masse* gives the pinkish color to the center of the disease spots.

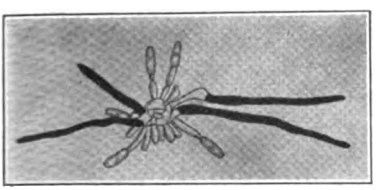

FIG. 51.—Portion of an acervulus showing conidia, conidiophores and setae.

The mycelium is slender (1.5 to 6 mu. in diameter), hyaline, much branched and sparingly septate. The branches in artificial culture arise at almost right angles from the parent branch (Fig. 50). The characteristic, greenish black appressoria of the anthracnoses are found.

The small, numerous hemispherical acervuli are brown to black until that color is obscured by the pinkish spores.

The setae (Fig. 51), which may number from one to twelve, or which in

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many instances are entirely absent, are long, irregular, slender, tapering toward an acute point. They are dark colored throughout, rigid, septate.

The spores are regular, oblong, continuous with obtuse ends, borne upon slender hyaline conidiophores. The spores germinate very readily in almost any medium, sending out from one to three germination tubes each.

The fungus was very readily isolated by planting a suspension of spores from figs, as they came into the laboratory, in 4 per cent pea agar. These cultures produced great quantities of acervuli, from which, by replating, characteristic pure cultures were obtained. These were used for inoculations in both laboratory and field.

INOCULATIONS.

In the laboratory two methods of inoculation were followed: 1. Spores were rubbed upon the surface of the fruit. 2. The fruit was pricked with a sterile needle and the spores introduced into the injured spot. In both cases the spots characteristic of the disease were produced a day or two later, the fruit being kept in a culture chamber.

In the field a suspension of spores in water was sprayed upon a bush in fruit. Fifteen or twenty days afterward no indication of infection was apparent, but specimens showing no lesions when placed in sterile culture dishes in the laboratory, developed Colletotrichose after a few days in great abundance. Eight figs, placed in culture dishes, autoclaved, then inoculated, all showed the mycelium characteristic of the disease at and around the point of inoculation, the mycelium being much more abundant upon these sterilized figs than upon those not sterilized. In due time the salmon-colored spores of the disease appeared in numerous pustules on both sterilized and unsterilized fruits.

Further field inoculations made with an enclosed, moist atmosphere, September 26, 1908, showed rotten spots on October 1, although no fungus was visible. The fruit, all of which had fallen from the bush, was placed in sterile culture dishes in the laboratory, and at the end of three days all specimens showed the characteristic disease, and at the end of a week great masses of spores were visible.

It is clear from the inoculation experiments that this fungus will grow upon the fig, sterile or in natural condition, if in a humid atmosphere, but that it does not grow well upon raw figs in a dry atmosphere.

These results are in accord with our observations upon the distribution of the disease, which has been noted as yet only in exceedingly humid localities, as on our seaboard.

IDENTITY OF THE FUNGUS.

Upon the genus *Ficus* we find recorded four species of *Colletotrichum* and four species of *Glocosporium*, which are as follows, with the host plants indicated:

1. *Colletotrichum clasticae* F. Tassi, in leaves of *Fiscus elastica* Italy.

2. *Colletotrichum clasticae* Zimm., in leaves *F. elastica*. Koorders says this is identical with *C. elasticae* F. Tassi.[2]

3. *Colletotrichum Fici-Elasticae* Zimm., in leaves *F. elastica* Java.

[2]Botanische Untersuchungenuber einige in Java vorkommende Pilze, besonders uber Blatter bewohnende, parasitisch auf tretende arten (Verh. Von. Akad. von Wetensch te Amsterdam Tweede Sect. Dert. XIII 4, p. 264), also (Notizblatt d. Konig Bot. Gart. u. Mus. zu. Berlin-Dahlem, No. 40, Bd. IV, 1907).

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4. *Colletotrichum Fiscus*[3] Koord.

5. *Gloeosporium intermedium* Sacc. var. *brevipes* on leaves of *F. elastica*. Koorders says this is indistinguishable from *G. elasticae* C. & M.

6. *Gloeosporium elasticae* C. & M. on leaves of *Fiscus elastica*.

7. *Gloeosporium Beniaminae* Scalia on leaves of *F. Beniaminae* in Sicily.

8. *Gloeosporium fructigenum* Berk. in fig fruits, Sussex, England, 1864.[4]

Only one of these species is recorded as occurring upon the fig, *Ficus Carica*. itself, nor do any of these species seem to be the species found upon the fig in this State.

Aside from the presence of setae in the species under discussion, it also differs from each of the various species of *Gloeosporium*. Its spores are smaller than those of No. 5 and its basidia are narrower and shorter. Its spores are much smaller and of very different shape than those of No. 7. Its spores differ in shape and size from those of No. 6 and are smaller than those of No. 8.

This species differs clearly from each of the species of *Colletotrichum* also. Its setae are much shorter than those of No. 3, which also is separated from it by its crescent-shaped spores. It is distinguished from Nos. 1 and 2 by its shorter setae and smaller uncurved spores.

It is possible that this disease is the same referred to as an undescribed *Colletotrichum* in the Year-book of the U. S. Department of Agriculture, 1907, p. 581, or that it is identical with a *Colletotrichum* of fig fruit collected at Berkley, Va., in 1905 and thought by Mrs. Flora Patterson to be an undescribed species, though it is impossible in the absence of any description or specimen to be sure in this regard.

It seems desirable to recognize this as a new species of *Colletotrichum*, for which we propose the following name and characterization drawn from the fungus as growing upon the nearly ripe fig:

Colletotrichum Carica, n sp.

Acervuli brown, becoming black, hemispherical, numerous, small, 85 to 250 μ in diameter, bearing one to twelve or often no setae, setae long, irregular, slender, acute, dark throughout, rigid, septate, 2 to 6 μ, thick by 22 to 106 μ long; conidiophores, slender 1 to 2 μ wide, 45 μ long hyaline; spores, regular, oblong, obtuse, continuous, hyaline, 3.5 to 6.6 μ by 8.7 to 20 μ.

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[3]Now regarded as Neozimmermania Elasticae (Koodors, Bot. Unt Verh of Koninktijke Akad. v. Wetenschappen te Amsterdam Dert. XIII, No. 4, 1907).

[4]Cooke, Jour. Roy. Hort. Soc., 28, p. 29.

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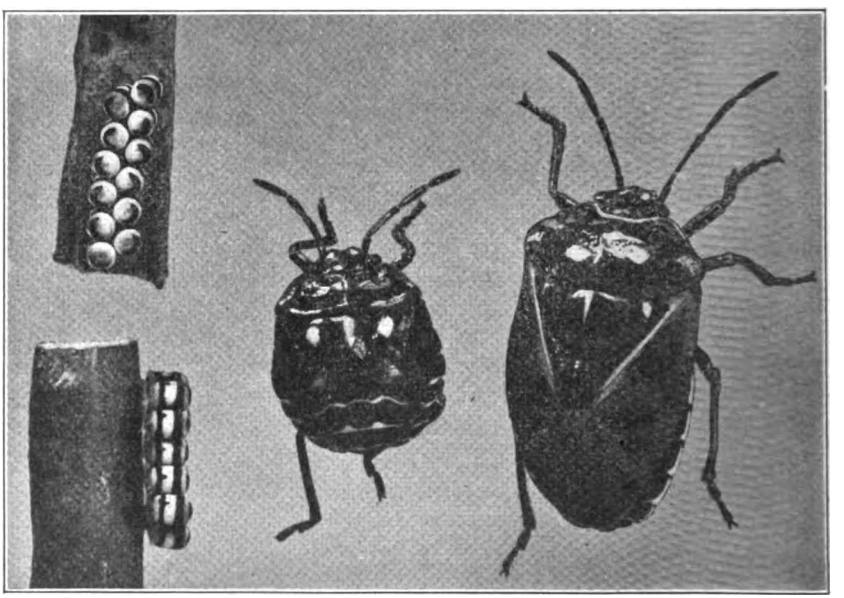
HARLEQUIN CABBAGE BUG (MURGANTIA HISTRIONICA).[1]

By R. I. Smith.

As an enemy of collard, cabbage, turnip, and related plants throughout the Southern States, none surpasses the harlequin bug in persistence and general destructiveness, in spite of the numerous remedies that are constantly printed in bulletins, agricultural papers and journals. The general failure to control this pest is partly the result of neglect, but is due largely to the farmers' lack of information concerning how the insect feeds, its rate of increase and remarkable power of surviving under unfavorable conditions. Realizing this



situation, the writer undertook, in 1908, a thorough study of the life-history and habits of this insect with a view to determining definitely the best methods of control. The results of this work, recorded in the following pages, reveal some facts hitherto unknown, which furnish a sound basis for the remedial suggestions which are made a part of this article.

Examination of the literature shows that some early writers make very erroneous statements concerning the number of annual generations and rate of increase. Later writers have frequently repeated these questionable statements, and, in general, entomologists have failed to make definite and complete observations on the most vital points in connection with this insect's life-history and habits. The writer's studies, although not complete in every

[1]Terrapin bug, collard bug, fire bug, calico bug, and sometimes other names of local adoption, are applied to this insect; but harlequin cabbage bug is the name by which it is most widely recognized in the various States where it occurs.

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respect, have resulted in obtaining information of considerable economic importance, because they show how and why the pest may be controlled by hand-collecting, spraying, and correct cultural methods.

DESCRIPTION.

The illustration shows the general appearance of eggs, young and adults. The latter have well-developed wings, with the dark portions black or metallic blue, and the lighter portion bright yellow in freshly transformed bugs, and red in the older individuals. The younger stages lack wings and vary somewhat in shape and appearance, in accordance with their age, but are readily recognized.

The eggs are set on end in masses of ten to fourteen, and resemble miniature barrels bound with two black hoops, as shown in the illustration.

GENERAL LIFE-HISTORY AND HABITS.

Winter Stage.—Harlequin cabbage bugs pass the winter in this state only as strong, mature adults, protected by whatever cover they happen to find. It seems probable that most of the bugs seek shelter in the fields where they were last feeding, but many find more favorable hibernating quarters under fences, buildings, rubbish piles, and in adjoining woodlands or thickets. A large number of the bugs that seek winter protection are unable to secure a favorable place, and consequently die, but a sufficient number survive, as is evidenced by their abundance each spring.

Eggs deposited in the fall too late to hatch, or bugs that fail to reach maturity before winter commences, do not live until spring.

Earliest Appearance.—The first warm spring days find the bugs issuing from their hiding quarters, and they may become active during a prolonged warm period in winter, but in 1908 it was the last of March before many bugs appeared. For the season's work the first definite observations and notes were made April 4, 1908, at West Raleigh, where all the work herewith recorded was done. The season was a little late, but bugs were then present in considerable numbers, although no eggs were discovered until a few days later, and the first young were found on April 14; hence this date is considered as approximately the beginning of the first seasonal generation. Some springs may bring forth adults at an earlier date.

Feeding and Mating.—Mating does not ordinarily take place until the bugs have fed from a week to ten days, but the first egg mass may be deposited the next day after mating. The females under observation in the laboratory mated usually the day before each egg mass was laid, but those confined without males laid just as regularly and in the normal manner. Mating occurs during the day, the pairs often remaining together several hours.

Egg-laying Habits.—It is generally supposed that twelve is the normal number of eggs deposited in each mass, being placed on end in two parallel rows of six each, closely cemented together, the eggs usually alternating like the cells of a honeycomb. As a matter of fact, the eggs are always placed on end, but a greater number are laid in more or less irregular masses than in two parallel rows of six each. Out of ninety-four egg masses laid in the laboratory by females under observation, sixty-two were irregular in form, but con-

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tained twelve eggs each, while only nineteen were regular with twelve eggs each, and thirteen masses varied in numbers from eight to fourteen. Twelve eggs for each mass is undoubtedly the average number, as evidenced by the fact that three females laid eleven once and thirteen in the following mass, while another laid ten and then fourteen eggs. In all instances observed where less than eleven were laid at one time, or where eleven eggs were deposited two or three times in succession, the female died shortly afterward.

The table—giving the egg-laying record—shows how often the egg masses are deposited, and it will be noticed that this time varies from two to fifteen days, but on an average of one mass about every four days.

Concerning the time consumed by a female in depositing the eggs, a marked regularity exists. I have watched several egg masses deposited and find it takes about thirty minutes to deposit twelve eggs. A quotation from notes made at the time will serve as an illustration:

"April 15, 1908, 4 P. M.—I have just watched and timed female of Pair No. 13, deposit a mass of twelve eggs. At 2:50 P. M. she was observed in the position assumed when about to commence deposition. She was apparently straining the abdominal muscles, and moved the abdomen up and down occasionally, during which process she frequently stroked the tip of her abdomen with either hind leg. During this process a drop of moisture appeared probably to serve as a glue for the first egg. At 2:56 P. M. the first egg was dropped, and the remaining number, making a regular mass of twelve in all, were deposited from 2:56 until 3:25, when the last egg appeared, or exactly twenty-nine minutes after dropping the first egg. Counting the six minutes that she remained in position preparatory to laying the first egg, it required thirty-five minutes for the whole process. The time elapsing between the appearance of each egg is almost exactly two and one-half minutes."

Incubation of Eggs.—The incubation period varies greatly with the temperature. Eggs deposited from April 9 to 15 required an average of eleven days, some requiring twelve days, while from May 12 to 21 the average was about six days. In hot summer weather they may hatch on the fourth day.

EGG-LAYING RECORD OF HIBERNATED INDIVIDUALS.

As already stated, these observations were commenced on April 4, when a very few eggs may have been present in the fields; hence of the fourteen pairs selected for the egg-laying record some may have deposited one mass. For this record, pairs were taken and confined in large glass vials with suitable food and a strip of blotting paper to absorb surplus moisture. It is my opinion that too little absorbent was used, the lack of which caused the premature death of some individuals. Six pairs were taken on April 4, and eight pairs on April 7. They were given fresh food (collard or cabbage) daily and the number of eggs were counted and removed each morning. As the eggs are laid during the daytime, the record is always one day behind as regards the actual date when the eggs were laid.

The shape of the egg mass, whether regular or irregular, and number of eggs, are represented in vertical volume in table, the letter "R" meaning regular, that is, two uniform parallel rows ("12-R" meaning twelve eggs in two rows of six each) and "I" meaning irregular ("12-I" meaning twelve eggs in an irregular mass).

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EGG-LAYING RECORD OF MURGANTIA HISTRIONICA. HAHN.

Date.	Daily Record of Fourteen Females of the Hibernated Generation.													
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.
1908. April 4														
5														
6														
7	12-I	12-R	12-R		12-I									
8				12-I		12-I								
9			12-I			12-I		12-R	12-I	12-I				
10	12-R	12-I			12-I									12-I
11			12-I				12-I			12-I		12-R	12-R	
12				11-I							12-I			
13	12-R							12-R	12-I					
14		12-I	12-I		12-I	11-R				12-I				12-I
15														
16				13-R			12-I		12-I		12-I	12-I	12-R	12-I
17										12-I				
18														
19			12-I					12-I						
20	12-I	12-I			12-I	11-R						12-I		
21				12-R			12-I		12-I		12-R			12-I
22	12-I							12-R						
23			12-I		12-I				12-I			12-I		Died
24													12-I	
25		12-I				12-R				12-I	12-R	Died		
26				12-I					12-I				Died	
27	12-I		12-I		12-I	11-R	10-R	11-I						
28		5	Died							4				
29		3						13-I		Died	Died			
30								Died	12-R					
May 1	12-I			8-R										
2				Died	12-I									
3						Died								
4														
5		2												
6														
7		Died					14-I							
8														
9														
10									12-I					

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EGG-LAYING RECORD OF MURGANTIA HISTRIONICA. HAHN.—*Continued.*

Date.	Daily Record of Fourteen Females of the Hibernated Generation.													
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.
1908. May 11														
12	12–I				12–R									
13														
14									11–R					
15	11–R													
16					12–I				Died					
17														
18							12–R							
19	12–I				12–I									
20							12–I							
21														
22	12–I													
23					12–I									
24														
25	Died						12–I							
26														
27							12–I							
28					12–I									
29							12–R							
30														
31					12–I									
June 1														
2														
3							Died							
4					11–I									
5														
6														
7														
8														
9					12–I									
10														
11					Died									
Total Egg Masses	11	8	7	6	15	6	10	6	9	6	4	4	3	4
Total Eggs	131	70	84	68	179	69	120	72	107	64	48	48	36	48

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From the above record, we determine that the length of life of individuals varied from twenty-two to sixty-nine days in confinement; also that the number of eggs deposited varied in about the same proportion. As a matter of fact, it is probable that those females dying before depositing at least six egg masses would have lived longer under more favorable conditions. At the same time Nos. 2, 4, 8 and 10, females that deposited eggs quite irregularly toward the last, in all probability died of natural causes; hence it would seem that by counting the average of the number of eggs obtained from females depositing at least six egg masses, we would have a fair average number that might be laid under normal or natural conditions. Granting this to be a correct supposition, we have ninety-nine as the average number of eggs laid by each hibernating female.

EGG LAYING OF SECOND GENERATION.

To serve as a check on the egg-laying record of the hibernated generation and to determine which, if either, lays the greatest number of eggs during their lifetime, an attempt was made to get a similar record for individuals of the second seasonal generation. For this experiment nymphs in the last stage of development were collected from the field, taken to the laboratory, reared to adults and from them, on August 10, fourteen pairs were selected and isolated in 4-ounce bottles with suitable food. Unfortunately, the mortality among these specimens was quite high, due, I am now convinced, to an excess of moisture accumulating in the bottles. Consequently the record is not as satisfactory as might be wished for, but at the same time is rather interesting.

EGG RECORD OF FOURTEEN FEMALES IN SECOND GENERATION.

Out of this number separated on August 10, seven died between August 24 and 27, after laying from twelve to thirty-six eggs each. Three more died on August 31, September 4, and September 7, respectively, each one having laid thirty-six eggs. On September 21 another female died, at forty-four days of age from maturity, after laying four egg masses containing forty-six eggs in all.

There remained only three females out of the original fourteen, and as they laid a larger number of eggs and lived so much longer, their individual record seems to be of particular interest, and is as follows:

The female of Pair No. 8 became adult on August 7 or 8, lived until October 5, or fifty-eight days, and deposited seventy-two eggs, or a mass of twelve eggs each, on the following dates: August 20 and 24, September 8, 17, 21, and 26.

The female of Pair No. 9 became adult August 8, lived until October 10, or sixty-three days, and deposited seventy-one eggs, or a mass of twelve eggs each (except once, when only eleven eggs were found), on the following dates: August 20 and 29, September 2, 10 (eleven eggs), 17 and 21.

The female of Pair No. 10 became adult August 7 or 8, lived under observation until October 10, when she escaped, after depositing eighty-four eggs or seven masses of twelve eggs each, on the following dates: August 20 and 29, September 7, 11, 20, 25, and 29.

As already stated, it seems probable that the females that died so soon after maturity were killed by excessive moisture in the bottles. In other words,

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the moisture caused them to get fastened to the sides of the bottles, where they died in their struggle to loose themselves. As this experiment was followed closely, I feel confident in concluding that the average number of eggs deposited by the second brood is six or seven masses of twelve eggs each, or from seventy-two to eighty-four eggs. This is less than the average for the hibernating brood.

LENGTH OF LIFE CYCLE.

There is some variation in the duration of the young stages, particularly the 4th and 5th instars. Chittenden records the life cycle for bugs hatching in March, as seventy days, including the egg stage, which covered eleven days. My record of bugs that hatched on August 24 and 25 shows the life cycle, exclusive of the egg stage, covered from fifty-seven to sixty-five days.

The following table shows the record of four individuals which were kept in the unheated laboratory.

LIFE CYCLE OF FOUR INDIVIDUALS.

No.	Hatched.	End of First Instar.	End of Second Instar.	End of Third Instar.	End of Fourth Instar.	End of Fifth Instar. Becoming Adult.	Total No. Days.
1	Aug. 25	Aug. 30–31[1]	Sept. 7–8[1]	Sept. 15	Sept. 27	Oct. 23	59
2	Aug. 25	Aug. 30–31[1]	Sept. 7	Sept. 15	Oct. 2	Oct. 29	65
3	Aug. 24	Aug. 30	Sept. 7–8[1]	Sept. 16–17[1]	Sept. 26	Oct. 20	57
4	Aug. 24	Aug. 30	Sept. 7–8[1]	Sept. 16–17[1]	Sept. 30	Oct. 27	64

As evidence that the duration of the fourth and fifth instars may vary, it is only necessary to study the above table, and as further proof compare these dates with the time recorded by Chittenden, as above mentioned. He states: "The first or egg stage covered eleven days. The time from the hatching of the eggs until the first molt gave the first larval instar or nymph period seven days; the second instar required thirteen days; the third, eight days; the fourth, fourteen days; while the fifth or pupal instar covered seventeen days—a total of seventy days or ten weeks."

The life cycle of the first generation was not as long, and probably means that the food supply governs to some extent the rapidity of growth. The recorded dates are given below.

NUMBER OF GENERATIONS ANNUALLY.

Three full generations, and perhaps a partial fourth, are all that are produced in the vicinity of Raleigh. This assertion is based on notes secured by careful observation resulting in a discovery that the bugs maturing after September 1 do not lay eggs the same season, but, on the contrary, live during the fall, and hibernate when cold weather commences. Considering the large number of young bugs usually present in the fields during November, it is not strange that a full fourth and fifth generation has been credited to this species. Indeed, one writer has stated that there may be seven or eight. Having learned, however, that females may live and continue depositing eggs

[1]With these the molt occurred some time between 5 P. M. and 8:30 A. M. *the following day.*

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for more than two months, the presence of young bugs the last of November may be accounted for, and safely classed as belated individuals of the third generation.

In the spring of 1908 the earliest individuals of the first brood became mature on May 25, and deposited eggs nine days later. This showed that the first generation took at least fifty-one days, exclusive of the egg stage, to become full grown and commence to deposit eggs. At this rate, allowing four days for eggs to hatch, the first individuals of the second generation became mature fifty-five days later, or on July 29, and this would throw the first adults of the third brood well into September.

It should be understood that many eggs are laid during September, October, and even November, but my observations show that these are laid by females maturing before September 1. As a matter of fact, the generations overlap completely after the last of May, and there may be a difference of over two months in the age of individuals of each generation.

PREVENTIVE AND REMEDIAL MEASURES.

The harlequin cabbage bugs are by no means easy to control, but the possibility of preventing their presence in destructive numbers depends largely on the individual farmer or gardener. While the adults fly readily, they usually confine themselves to one locality as long as there is sufficient food, and for this reason the gardener who makes a vigorous fight against them in his own fields may depend upon it that no serious reinfestation will result from neighboring fields unless they happen to lie very close together.

The recommendations that follow are based upon the known habits of this pest with a view of taking advantage of their weakest points.

Winter Treatment.—Knowing that the adults hibernate during winter, the practice of clean farming suggests itself as a valuable preventive measure. It is a well-known fact that this pest is reduced to small numbers on large cultivated areas that are properly cleared of remnants of old crops, followed by fall, winter or early spring plowing. A good illustration has come under the writer's observation in the case of the farm of the Central Hospital, located at Raleigh. This farm embraces several hundred acres of cultivated land, of which a good many each year are devoted to the growth of cabbage, collards, and turnips, and which furnish extensive feeding ground for the harlequin bug. The manager advises me that he formally attempted to save seed from these crops, and while doing so the insects were very hard to control, but that he has now abandoned this, and consequently is enabled to get his fields cleaned up early in the fall. The result is that the bugs are not troublesome, owing to the small numbers that survive the winter. Similar results have been obtained on the farm of the Agricultural College. Farmers who allow a quarter or half acre of worthless plants to remain during the late fall months as food for harlequin bugs are simply inviting trouble.

Early Spring Destruction.—As a preventive measure, the destruction of the bugs that first appear in spring should be given first importance. We could not consistently urge this practice if the bugs commenced egg laying when they first appeared, but we know that about two weeks' time is devoted to feeding and to mating before eggs are deposited. As a general rule, the bugs

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appearing earliest congregate on a few plants, flowering mustard, turnips, or collards furnishing favorite feeding grounds. From such places they should be collected by hand, or killed with pure kerosene in case the plants are worthless. The true value of this practice is illustrated by considering the following:

Rate of Increase.—As an illustration of the benefit derived from destroying the bugs before they have commenced to lay eggs, we see by referring to the egg-laying record, that each female deposits an average of about one hundred eggs. There are three full generations annually. Suppose we kill a single female and thus prevent one hundred young of the first generation, of which one-half might be females. If these fifty reproduced at the same rate the second generation would number 5,000, and counting only one-half of these as females, each capable of producing one hundred young, the third generation would reach the enormous number of 250,000, the progeny of one female in a single year. We can divide this number by 100 and still have 2,500 as the number of bugs prevented by killing one individual when she first appears in spring.

During the warm summer months a large per cent of the eggs are destroyed by a minute parasite in the form of a tiny black fly; but as a general rule, they do not become abundant until the first generation is well developed, so that the destruction of the bugs that produce that generation will result in greater benefit than similar work later in the year.

Hand Picking.—During the summer months harlequin bugs are liable to occur in small numbers, even where the previous recommendations have been followed, and to prevent their increase, collecting by hand is the most profitable remedy. Progressive truckers employ children for this work and find it pays better than to let the bugs increase until spraying becomes necessary.

Spraying.—Kerosene emulsion of 15 per cent strength may be used to kill small or half-grown bugs, and is also somewhat effective against the mature forms. However, when the bugs are sufficiently numerous to make spraying profitable, much injury has usually been done, and this situation should be avoided by the methods already suggested.

When kerosene emulsion is employed it should be applied with a good spray pump, forcing the spray under high pressure, knocking the bugs to the ground and covering them where they lie. Some adult bugs will always survive, necessitating a second or third treatment.

Harlequin bugs feed entirely by sucking, and arsenical poison sprays are therefore useless. Kerosene emulsion kills by contact, so unless the individual bugs are hit by the spray, they will not be killed.

Fall Destruction.—Toward the end of every season, harlequin bugs frequently become numerous on remnants of crops that are of little or no value and usually no attempt is made to destroy them. From what has already been stated, it is evident that they are the ones that will pass the winter. Here, then, is an opportunity to destroy large numbers that would otherwise have to be collected the following spring; in this case the suggestion is again based on the life-history of the insect, that is, the fact that those maturing after about September 1 do not lay eggs the same fall. During October and November, there is ample time to destroy the bugs to protect the following year's crop.

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In the opinion of the writer, time put in this fall destruction will prove to be well spent and should be considered as an essential part of the fight against this pest.

This work may be accomplished by hand collecting, spraying or cleaning off remnants of crops, followed immediately by deep plowing. Every adult killed in the fall may mean one less the following spring, and the aim should be to prevent their going into hibernating quarters.

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IS NEOCOSMOSPORA VASINFECTA (Atk.) SMITH, THE PERITHECIAL STAGE OF THE FUSARIUM WHICH CAUSES COWPEA WILT?

By B. B. HIGGINS.[1]

One of the first wilt diseases to be attributed to the Fusarium type of fungi was a disease of cotton described by Atkinson[2] in 1892. The wilting of the cotton was attributed to the plugging of the vessels of the plant near the base of the stem by the mycelium of a fungus. This fungus was isolated and described by Atkinson[2] as a new species of Fusarium under the name *Fusarium vasinfectum.*

Atkinson also found a Fusarium on the surface of some of the sick plants, but considered this a saprophyte distinct from the internal fungus.

A few years later (1894-1899) Erwin F. Smith made a much more extensive study of the wilt-producing Fusaria on cotton, also on watermelon and cowpea.[3] He found an internal fungus plugging the vessels of the stems, and producing in them (melon and cowpea) short hyaline, nonseptate (or occasionally, once or twice, septate) spores, microconidia. The Fusarium was found in all three host plants, cotton, watermelon, and cowpea, and was considered by Smith to be specifically identical with *Fusarium vasinfectum* Atk.

After the plants infected with internal fungus had died, another spore form, "macroconidia," appeared on the surface of the stems. This form is described by Smith[1] as consisting of lunulate, 3 to 5 septate spores, 30 to 50 by 4 to 6 mu., which are borne on the surfaces of dead stems in immense numbers or on innumerable, small, oval, or hemispherical conidia beds which arise from the internal mycelium and consist of compact, irregularly branched, short conidiophores. The spores, when germinated in water or in acid or alkaline agar or in very moist air, are said to produce conidia indistinguishable from those borne by the internal fungus.

The enlarged cells in the hyphæ of the fungus described by Atkinson as resembling gemmæ were also noted by Smith on stems of watermelon, and cultures of the fungus from melon and cotton and were regarded as clamydospores.

Smith also found red perithecia growing on the roots and stems of cotton, watermelon, and cowpea.

All four of these fungous forms were considered by Smith to be stages in the life-history of one fungus, which he named from its ascogenous stage *Neocosmospora vasinfecta.*

[1][The investigation upon which this article is based was begun by Mr. Higgins, at the suggestion of Dr. Stevens, to form material for a Master's thesis. The preliminary studies revealed a problem of unexpected significance and led to modification of the original plan and to the devotion of a portion of Mr. Higgins' time as laboratory assistant of the Experiment Station to the completion of the investigation. The research was thereafter carried on under the direction of Dr. Stevens, partly as Station work and partly in pursuance of college study.—DIRECTOR.]

[2]Some Diseases of Cotton. Ala. Sta. Bul. 41, pp. 19-29.

[3]Wilt Disease of Cotton, Watermelon, and Cowpea. Bul. No. 17, U. S. Dept. of Agr., Div. of Veg. Phys. and Path.

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Smith's conclusion as to the genetic relationship of these fungous forms has been generally accepted, although only a very few writers have reported actually finding the perithecia,[2 17] and no one, so far as I can find, has by means of pure cultures corroborated Smith's conclusions.

Whether Smith did or did not succeed in producing perithecia from the internal fungus taken from the stems of the cowpea, is not quite clear. In Bulletin 17 (Div. of Veg. Phys. and Path., U. S. Dept. of Agr., p. 11) he says: "No perithecia ever developed in any of the cultures made from internal or external conidia taken from the cotton or watermelon."

Thus, although denying perithecial production by conidia taken from watermelon and cotton, he does not deny perithecia production by conidia from the cowpea fungus. From this, one might be led to infer that perithecia were obtained from conidia taken from the cowpea. The only positive statement of the production of perithecia from conidia is made on page 10 of the above-mentioned bulletin, where he says: "Perithecia have also been produced from 150 or more microconidia. They were isolated by the poured plate method, the material being derived from an agar culture about two weeks old which was made from ascospores." No statement is made as to whether the culture producing these ascospores was obtained originally from the internal fungus or from the outer perithecial fungus.

With these facts in mind, the present work was begun in the fall of 1908 in the laboratory of the Station, to learn so far as possible the exact conditions under which perithecia are produced, and if possible to obtain perithecia from pure cultures of the internal fungus from cowpea stems.

There has long been much question as to why certain imperfect fungi, *e. g.*, *Colletotrichum gossypii*, *Glœosporium fructigenum*, etc., produce perithecia abundantly under almost any conditions, while other strains of what is apparently the same fungus do not produce perithecia at all. Again, the perithecia-producing power seems to come and go in the same strain. It was hoped by the study of selected pedigree cultures to throw light upon this point regarding the forms under discussion.

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[1]Smith lc.

[2]Butler, E. J., Fungous Diseases of India in 1903. Ztschr. Pflanzenkrank. 15 (1905), pp. 44-48.

[3]Delacroix, G., Cotton Disease in Egypt. Agr. Prat. Pays Chauds, 2 (1902), No. 8, pp. 135-143; Jour. Agr. Trop. (1902), No. 14, pp. 231-233.

[4]Delacroix, La Maladie des osillets d'Autibes. 1901.

[5]Delacroix and Maublanc, Encyclopedia Agricole Maladies Parasitaires des Plants Cultivates (*Neocosmospora vasinfecta*), pp. 333-334.

[6]Duggar, B. M., Fungous Diseases of Plants, pp. 233-239.

[7]Evans, G., Cotton Wilt in Central Provinces. Agr. Jour. of India, 3 (1908), I, pp. 78-80.

[8]Fletcher, F., Notes on Two Diseases of Cotton. Jour. Khediv. Agr. Soc. and School Agr., 4 (1902), 6, p. 42.

[9]Jaczewski, A. von, On the Occurrence of the Wilt of Sesame. Ann. Mycol., I (1903), I, pp. 31-32; abs. in Bot. Centbl. 92 (1903), 23, p. 543.

[10]Lewis, A. C., Black Root Diseases of Cotton in Georgia, and Its Control. Ga. Bd. Ent., Bul. 28.

[11]Malkoff, K. A., Plant Diseases and Other Injuries to Cultivated Plants. Ghod. Otchet. Drzhav. Zeml. Opitna Stanz. Sadovo. (Jahresber. Staatl. Landw. Vers. Stat. Sadovo) 4 (1906).

[12]Orton, W. A., Some Diseases of the Cowpea. Bul. 17, Bur. of Plant Industry, U. S. Dept. of Agr., pp. 9-23.

[13]Orton, W. A., A Study of Disease Resistance in Watermelons. Abs. in Science, n. ser. 25 (1907), 634, p. 288.

[14]Orton, W. A., Cotton Wilt. U. S. Dept. of Agr., Farmers' Bul. 333, pp. 5-54.

[15]Reed, H. S., Parasitism of *Neocosmospora vasinfecta* Science, n. ser. 23 (1906), 593, pp. 751-752.

[16]Smith, R. I., and Lewis, A. C., Black Root Disease of Cotton. Ga. Bd. Ent., Bul. 22, pp. 237-275.

[17]Sorauer, P. Handbuch der Pflanzenkrankheiten, Dritte Auflage, p. 204.

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Abundant material was found in the fields of the College and Station farms. Externally, the diseased cowpea plants presented the characteristic wilted appearance as fully described by Orton.[1] Internally, the woody portion of the stem near the ground was browned and the characteristic conidia-bearing mycelium was found in the vessels.

After the plants had died, innumerable small, roundish, salmon-colored spore clusters appeared on the surface of the stems. These tufts were made up of large sickle-shaped, 3-5 septate spores, borne on the ends of short, irregularly branched hyphæ (Figs. 2 and 3).

For convenience in distinguishing the different fungous forms found in or on the cowpea stems, the fungus found in the ducts of the plants will hereafter be designated the "internal Fusarium"; the spore clusters found on the surface of dead stems will be called the "external Fusarium"; and the ascigerous form will be mentioned as such.

The work for the first month was confined almost entirely to searching for red perithecia, described by Smith.[1] The stems and roots of hundreds of sick or dead plants from various fields were examined. A great many stems and roots were also brought to the laboratory and placed in tubes with the hope that perithecia would develop upon them; yet, all these early searches for perithecia were unsuccessful.

On October 31, 1908, pure cultures of the internal Fusarium were obtained by aseptic transference of the mycelium from inside the stems to plates of cowpea-leaf agar.

From these original cultures very numerous transfers were made to study the effect of different media upon the fungus. The fungus (internal Fusarium) was grown on cowpea agar, cowpea-leaf agar, carnation agar, Irish potato, rice, and stems of green cowpeas.

Of the last-named medium more than two hundred tubes were prepared and inoculated, as follows:

Stems of almost mature cowpea vines were cut in pieces 10-12 cm. long and placed in test tubes containing about 3 cc. of water. They were then autoclaved at 120° C. for twenty minutes. All were inoculated with mycelium of the internal fungus.

This medium, it would seem, should give the nearest possible approach of any medium to the natural food and environment of the fungus. The ascigerous stage never appeared, however, although the tubes were kept and examined at intervals for more than four months. Neither did the ascigerous stage appear on any of the other media.

On the same day that the original isolation was made (October 31) pieces from three diseased stems were placed in test tubes and set away in the laboratory.

The perithecia of a great many ascigerous fungi (Melanospora being specially abundant) developed on these stems. After about two months a few bright-red perithecia appeared on one of the stems. On examination, they were found to agree in every particular, size, shape, color, and general structure of perithecia, of asci, and of spores, with Smith's[2] description of the perithecial stage of *Neocosmospora vasinfecta*.

On January 16 one of these perithecia was crushed, placed in a tube of melted pea agar, and poured into a Petri dish. When the ascospores began

[1] Orton, lc.
[2] Smith, lc.

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to germinate, one of the germinating spores was lifted out with the aid of a dissecting microscope, and transferred to another plate. In about a week from the time of sowing spores very small colorless perithecia appeared around the center of the colony; the second day after the perithecia were first noticed they began to turn red, and by the end of another week they were of a bright-red color and contained ascospores. Short, hyaline, continuous or once septate conidia (microconidia of Smith)[1] were also produced in abundance. This colony was kept pure, and from it the material for the first transfers in pedigree cultures was obtained. It therefore constitutes generation No. 1 in this experiment. In all, fifty-four colonies were produced from this one perithecium, and every colony produced both perithecia and conidia.

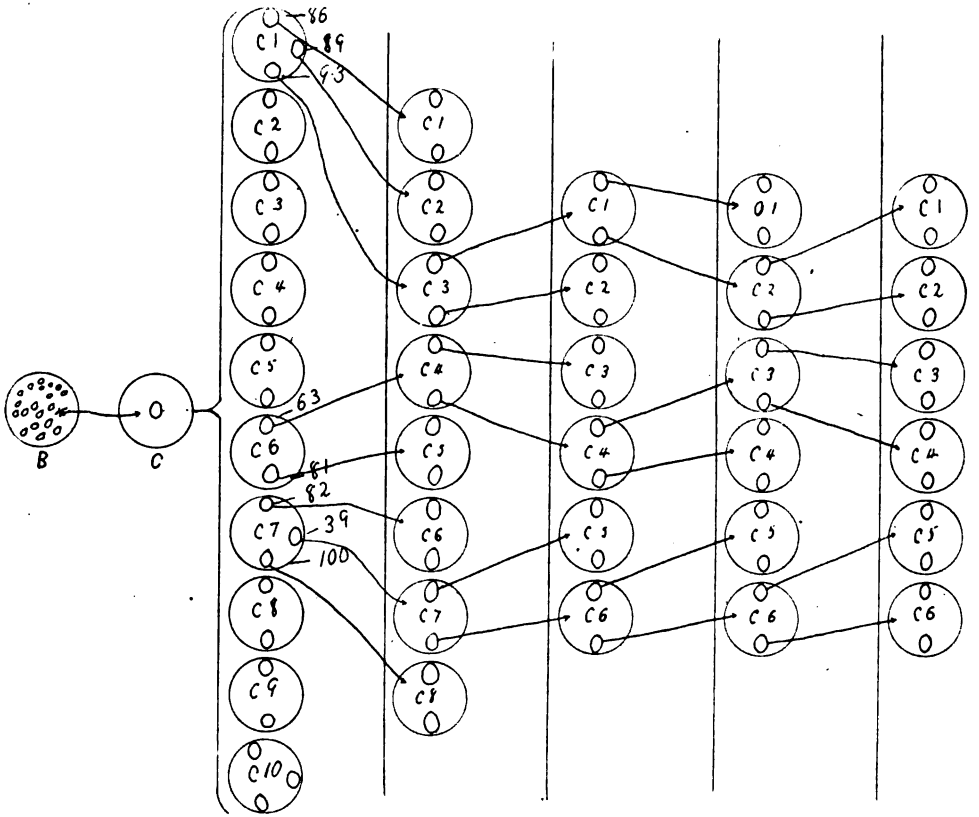

FIG. 1.—Pedigree diagram, showing method of recording the pedigrees of the cultures; *b*, culture from original perithecium; *c*, single colony from *b*, generation No. 1. Numbers within the circle are the numbers of the plates.

Pedigree Cultures.—By pedigree cultures is meant, cultures in which the parentage (whether ascosporic, conidial, or mycelial) of any colony can readily be traced back to the perithecium taken from the cowpea stem. Concerning these pedigree cultures, records were kept of all marked variations in every colony. The parentage records were kept by means of diagrams, which were meant so far as possible to show graphically the manner in which each transfer was made (Fig. 1).

[1] Smith, lc.

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It was suggested by Smith that remoteness of origin from the ascospore might interfere with the perithecia production of this fungus. It was also suggested to the writer that by taking advantage of small variations of the fungus in the direction of lessened perithecia production, it might be possible to produce a strain which would not produce perithecia at all.

To test these two points, transfers to new media were made from the original colony (generation No. 1) in three ways:

1. Bits of mycelium bearing no conidia were transferred from the extreme edge of the colony.

2. Conidia were transferred by adding a drop of water to a conidial region, then with platinum loop transferring an oese of this water to new media.

3. Ascosporic transfers were made by crushing perithecia in sterile water on a sterile slide, then after careful examination, under a microscope, to see that no conidia were present, transfers were made with a loop to new media.

Thus, from the single colony of generation No. 1 the following transfers were made: January 30, seven mycelial transfers; February 6, ten conidial (microconidia) transfers; and February 11, fourteen ascosporic transfers. The resulting cultures constitute generation No. 2.

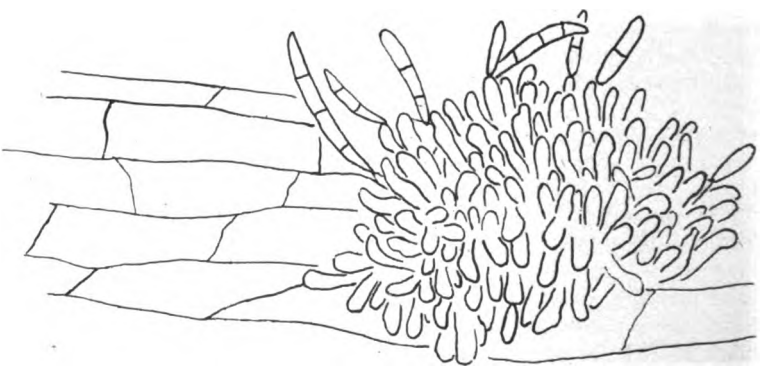

FIG. 2.—Conidia bed from surface of cowpea stem killed by wilt; showing tufts of conidia-bearing hyphæ and sickle-shaped conidia, macroconidia.

On February 11, fourteen mycelial and twenty-eight conidial transfers were made from the seven mycelial cultures of generation No. 2. On February 22, sixteen mycelial and sixteen conidial transfers were made from eight of the conidial cultures of generation No. 2.

In these eight colonies there was a slight variation in number of perithecia produced per colony, due possibly to bacterial contamination in some of the plates. Colony No. 1 produced eighty-six perithecia; No. 2, ninety-three; No. 3, eighty-nine; No. 4, sixty-three; No. 5, eighty-one; No. 6, eighty-two; No. 7, thirty-nine, and No. 8 produced one hundred perithecia. No. 4 and No. 7 were both badly contaminated with bacteria. Cultures of both conidial and mycelial origin produced perithecia uniformly and in apparently equal numbers.

Since this time only three straight lines of transfers have been made, that is, mycelial transfers made from mycelial colonies, conidial transfers from conidial colonies, and ascosporic transfers from ascigerous colonies. This has continued in case of the mycelial and conidial lines through six generations, and the ascosporic line has been carried through five generations.

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The mycelial and conidial transfers were made about every two weeks, when the plate was nearly covered by the colony. The ascosporic transfers were not made until spores were fully mature, emerged naturally and collected in dark-brown masses around the osteolum, which occurred in about three to four weeks after inoculation.

So far there has been no apparent loss of power to produce perithecia in either the conidial, mycelial, or ascosporic lines, nor any marked variation in this respect.

To test the effect of different media on perithecia production, inoculations were made onto plain agar, cba[1], cba+sodium asparaginate+glucose, cba+starch, and cba+glucose. All these media produced perithecia. They were produced most abundantly on cba+sodium asparaginate+glucose and least abundantly on plain agar.

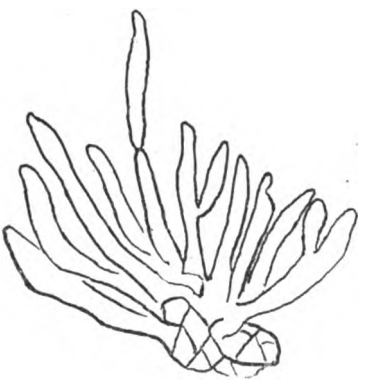

FIG. 3.—Small portion of conidia bed, showing irregular branching of hyphæ.

To see if these changes in perithecia-producing power were permanent, cross inoculations were made upon the two media. Two plates of plain agar and two of cba+sodium asparaginate+glucose were inoculated from a colony which had produced nine perithecia per square centimeter on plain agar. A like number of plates was inoculated from a colony which had produced one hundred and seventy perithecia per square centimeter on cba+sodium asparaginate+glucose. Practically the same number of perithecia was produced from each inoculation, six per square centimeter on plain agar and one hundred and sixty-seven per square centimeter on cba+sodium asparaginate+glucose.

These results indicate that the amount of nourishment does not affect permanently the perithecia-producing power of the fungus. It was noticed, further, that the number of perithecia produced varied about proportionately to the amount of mycelial growth. That is, when grown on a medium rich in nutrients (such as cba+sodium asparaginate+glucose) the fungus made a luxuriant growth of mycelium and produced perithecia abundantly, while on media poor in nutrients (such as plain agar) it made a thin, scanty growth of mycelium and produced proportionately few perithecia.

Alkaline Rice.—Tubes of rice were prepared and made alkaline as follows: 8 grams of rice were weighed into each tube, two cubic centimeters of a satu-

[1]cba signifies Chemical Base Agar. For details of composition, see article by Stevens and Hall, "Variations of Fungi Due to Environment." Bot. Gaz. 48; pp. 1-30.

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rated solution of sodium carbonate added, and autoclaved for twenty minutes at 120° C. These tubes were then inoculated with ascospores. After fifteen days a slight whitish growth could be seen on the surface, and in another week it had covered the surface of the rice. At the end of sixty days a grayish white to dark steel-gray stroma covered the surface of the rice and an abundance of small colorless conidia was found. The stroma, however, showed no perithecia even under careful microscopic examination. At this time (sixtieth day from inoculations) some of the mycelium with conidia was transferred to plates of cowpea-leaf agar. In a few days perithecia appeared in abundance on the new growth. On the ninetieth day transfers were again made from the alkaline rice to agar, with the same results.

The ascigerous fungus was grown on a great many other media, viz., asparagus agar, carnation agar, steamed potato (both Irish and sweet), rice, steamed cowpea stems (both green and cured), and gelatine. Perithecia were produced abundantly on all these media.

EFFECT OF HEAT UPON PRODUCTION OF PERITHECIA.

Twelve agar plates were inoculated; six were placed in an incubator at 27° C. and the other six were left in the open room.

Perithecia appeared on the plates in the incubator in forty-eight hours, while they did not appear on the other plates until the sixth day; but the ultimate number of perithecia produced was practically the same in each case.

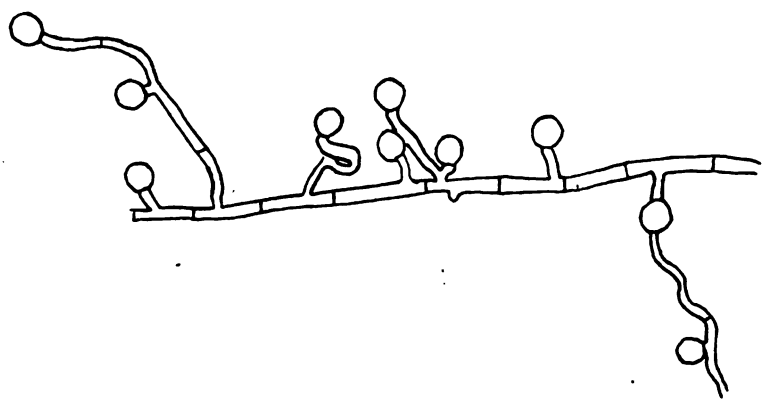

FIG. 4.—Mycelium, bearing several clamydospores from old pea agar culture of internal fungus.

In none of the experiments above recorded was there any evidence of any tendency of a given strain of the fungus to alter its power of ascus production, nor was there evidence that external conditions exert any permanent influence upon this power.

Smith's[1] evidence that the two forms are genetically connected did not seem to the writer to be entirely conclusive. Since Smith's bulletin setting forth his conclusions treats of wilt of cotton, watermelon, and cowpea, it is not always clear what evidence he claims in the case of each separate host. Careful reading shows that all the clear evidence definitely referring to the fungus upon the cowpea that can be found in his bulletin is comprised in the two facts, that

[1]Smith, lc.

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perithecia of Neocosmospora are frequently found on the plants which have been killed by the internal fungus, and that ascospores from these perithecia produced conidia which very much resemble the microconidia of the internal fungus.

As to the first of these facts, such occurrence of perithecia is altogether too rare to have very great weight as evidence that the two fungous forms are genetically connected. Smith[1] reports the wilt disease from eleven localities, while the perithecial stage is only reported from three of these.

Atkinson reports the cotton wilt from seven localities, but does not report any perithecial stage. Since that time wilt disease caused by a Fusarium very similar or identical with *Fusarium vasinfectum* Atk. have been studied by many pathologists in diverse sections of the world; but, so far as I can find, no one except Smith and Orton has reported the ascigerous stage of Neocosmospora in connection with them. In my own experience, the Neocosmospora perithecia have been found on only three plants. In the fall of 1908 stems of a great many diseased plants were put up in test tubes. Only one of these developed perithecia. Of fifty stems and roots put up in this way in 1909 only two developed perithecia of Neocosmospora.

The perithecia of several other ascigerous fungi (notably, Melanospora) were found much more frequently on these stems than was Neocosmospora. Although hundreds of cowpea stems dead or diseased by the Fusarium wilt have been examined, I have never found the perithecial stage of Neocosmospora in the field.

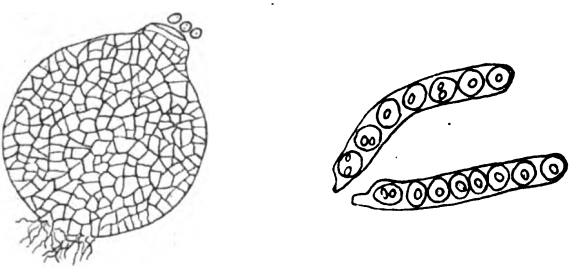

FIG. 5.—Perithecium from artificial culture on cowpea stem (perithecium x 50, asci x 280).

Smith[1] also stated further: "In the interior of these plants, both in the vessels and in parenchyma cells, there was an abundance of mycelium bearing great numbers of small colorless (white) elliptical microconidia, and at the same time, on the outside, on the salmon-colored conidia beds, enormous numbers of big lunulate, 3 to 5-septate macroconidia, the hyphæ of the fungus being readily traceable outward from the plugged or partially occupied vessels of the plant to the conidia beds on the surface." This, however, cannot be considered as evidence that the internal fungus is genetically connected with Neocosmospora; because Neocosmospora does not produce these large lunulate 3 to 5-septate spores such as are found in the external conidia beds.

COMPARATIVE CULTURES.

While making cultures such vast differences were observed between the general appearance of the internal fungus and that of the ascigerous fungus that

[1]Smith, lc., p. 33.

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it was thought best to make a comparative study of these two fungi to see if the differences were constant and would appear when the two fungi or strains were grown on the same media and under the same environment. The comparative cultures were made on pea agar, gelatine, rice, Irish and sweet potatoes, stems from cured cowpea hay, and stems from green cowpeas.

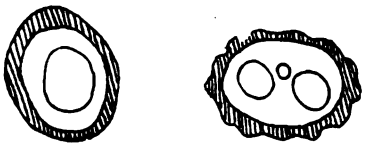

FIG. 6.—Ascospores, from Irish potato; the surface of one roughened, the other smooth (x 1050).

On Pea Agar the internal fungus made a profuse white aërial growth and large sickle-shaped 3 to 5-septate conidia, macroconidia, were produced abundantly over the surface of the medium. At the point of inoculation a rather large yellow cluster of these macroconidia was always produced. Small 1-septate or continuous conidia, microconidia, were also found in abundance.

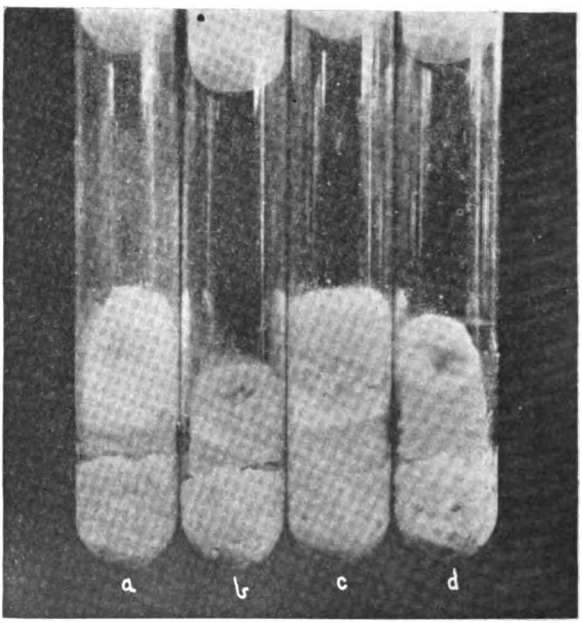

FIG. 7.—Cultures on Irish potato, 8 days after inoculation, showing difference in growth of internal fungus tubes, *a* and *c*, and ascigerous fungus tubes, *b* and *d*.

The ascigerous fungus produced an almost colorless, strict growth. No yellow spore clusters were ever produced and no 3 to 5-septate conidia were ever found. Small, hyaline, continuous or once septate conidia, very similar to the microconidia of the internal fungus, were found in abundance.

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On Rice.—Probably the most striking differences shown on any medium were the different colorations produced by the internal fungus and the ascigerous fungus, particularly on rice.

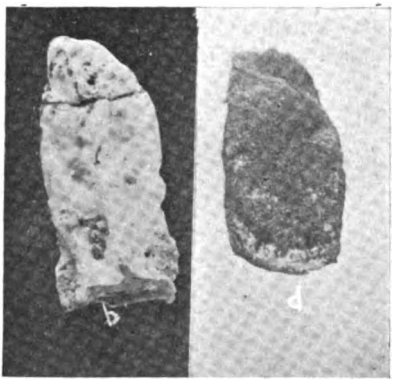

FIG. 8.—Old Irish potato cultures—*b*, internal fungus, showing sclerotia and white floccose growth; *d*, ascigerous fungus, showing numerous perithecia and scant mycelial growth.

Eight tubes of boiled rice were prepared as follows: Eight grams of rice were weighed into each tube and two cc. of water added. The tubes were then autoclaved twenty minutes at 120° C. and inoculated; four with conidia from agar cultures of the internal fungus and four with the ascigerous fungus.

FIG. 9.—Section of sclerotium showing compact mycelial structure (photo micrograph).

The internal fungus again made a much more vigorous, profuse growth. On the fourth day from inoculation a few grains in the top of tubes inoculated with the internal fungus began to turn red. The red color gradually passed down until all the rice in the tube showed some shade of red, from light rose to deep blood-red. As the cultures aged, the coloration gradually deepened until (generally, third or fourth week) it was a bluish purple. As the rice dried out and shrank away from the sides of the tubes a profuse cottony growth of mycelium was generally produced. Macroconidia were produced, but not so abundantly as on agar. Microconidia were very abundant.

In the tubes inoculated with the ascigerous fungus the coloration began as with the internal fungus; except that it was about two days later in appearing, and, instead of turning the rice red, it was changed to a dirty brown color. This did not change further, except possibly to become slightly darker

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brown as the rice dried out. Perithecia were produced quite freely, but they were not so red as on potato and most other media. The short uniseptate spores were quite abundant. No sickle-shaped 3-5 septate conidia were found.

On Gelatine stab cultures the internal fungus made a rapid growth, entirely covering the surface of the medium in seven days with a profuse, white, aërial growth, which changed to a light pink color at the end of two weeks. Some growth was made throughout the full length of the stab.

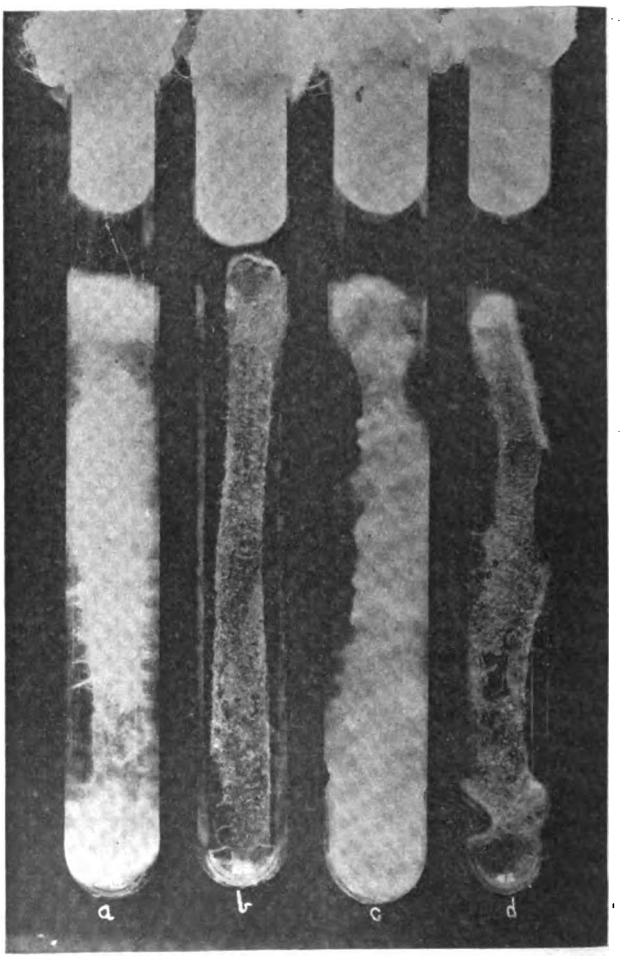

FIG. 10.—Cultures on green cowpea stems showing luxuriant white growth of internal fungus, tubes *a* and *c*, and scanty grayish growth of ascigerous fungus, tubes *b* and *d*.

The ascigerous fungus made a very slow growth. Fourteen days were required for the strict, light brownish mycelial growth to cover the surface of the medium; three weeks to cover it with a mass of blood-red perithecia. No growth was made below the surface of the gelatine.

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On Potato.—The internal fungus made a very profuse white aërial growth, while the perithecial fungus made a slow growth of grayish mycelium which was only slightly aërial. This difference of growth is shown in Figs. 7 and 8, which represent two tubes of each fungus six days after inoculation. The mycelium of the internal fungus began to turn pink after it had grown seven days, and yellow clusters of spores appeared at points over the surface of the

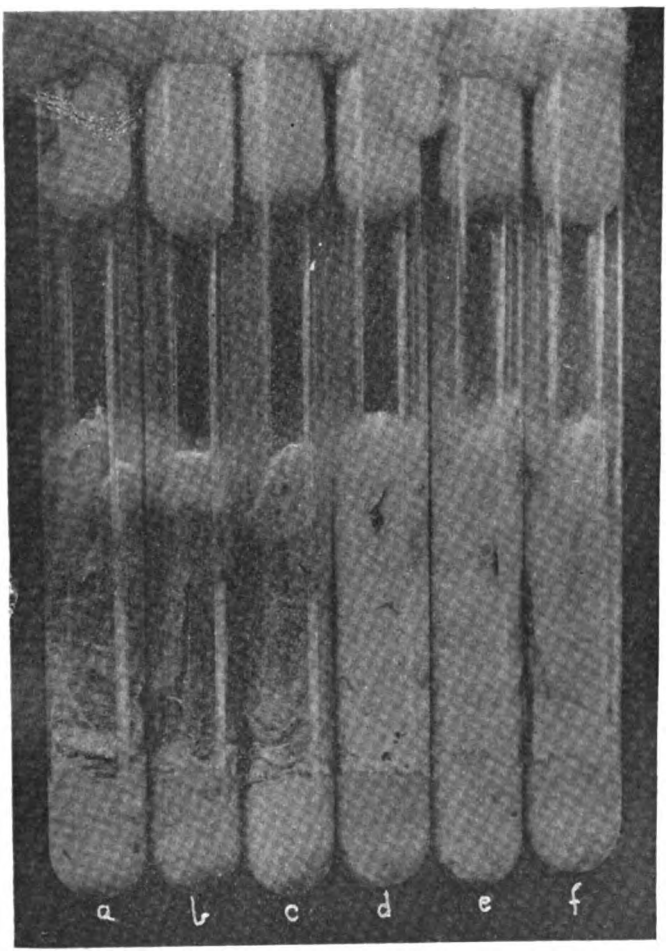

FIG. 11.—Cultures on stems of cured cowpea hay, showing luxuriant white growth of internal fungus, tubes *d*, *e* and *f*, and scanty mycelial growth and abundant perithecia of external fungus, tubes *a*, *b* and *c*.

potato. What appears to be sclerotia (Figs. 8 and 9) were also produced on every potato inoculated with the internal fungus. Four days after inoculation with the ascigerous fungus onto potato a cluster of almost colorless perithecia could be seen at the point of inoculation. This cluster gradually widened and became darker until at end of two weeks the whole surface was covered with a mass of brick-red perithecia. No yellow spore clusters or sclerotial bodies were produced by the ascigerous fungus.

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On steamed stems of cowpea hay the growth of both fungi was very similar to that on Irish potato. The internal fungus produced many yellow spore clusters and also many small black sclerotial bodies similar to the bodies produced on the potato, except that those on the pea stems were much smaller. The perithecial fungus again produced a light grayish growth of mycelium and many bright-red perithecia, but no yellow spore clusters and no sclerotia.

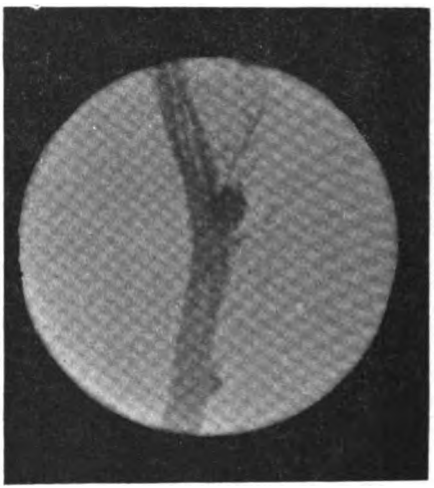

FIG. 12.—Portion of compact rhizomorphic strand of the fungus from sweet potato culture of ascigerous stage; *a* is a young perithecium (photomicrograph).

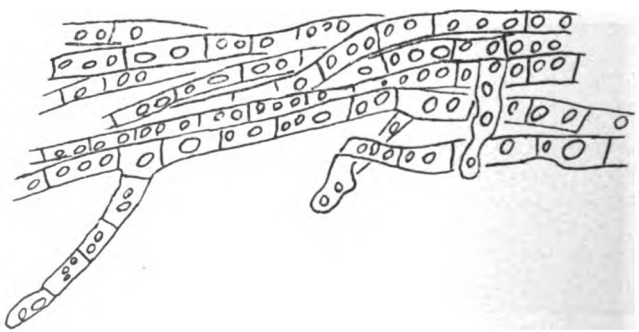

FIG. 13.—Portion of tip of rhizomorphic strand similar to Fig. 12 (x 385).

On autoclaved green cowpea stems the internal fungus rapidly made a very profuse cottony growth of mycelium (Fig. 10), tubes *a* and *c*. Comparatively few conidia of any kind were produced. Both micro- and macro-conidia were found.

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The ascigerous fungus made very poor, scanty growth at first. Even two weeks after inoculation scarcely any mycelium could be seen. By the end of the third week, however, the growth of mycelium had become more prominent (Fig. 10, tubes *b* and *d*) and perithecia began to appear abundantly. The mycelium, however, was of a grayish white color and never became so floccose or profuse as that from the internal fungus. No macroconidia were found.

On Sweet Potato the growth of the internal fungus was very similar to that on Irish potato.

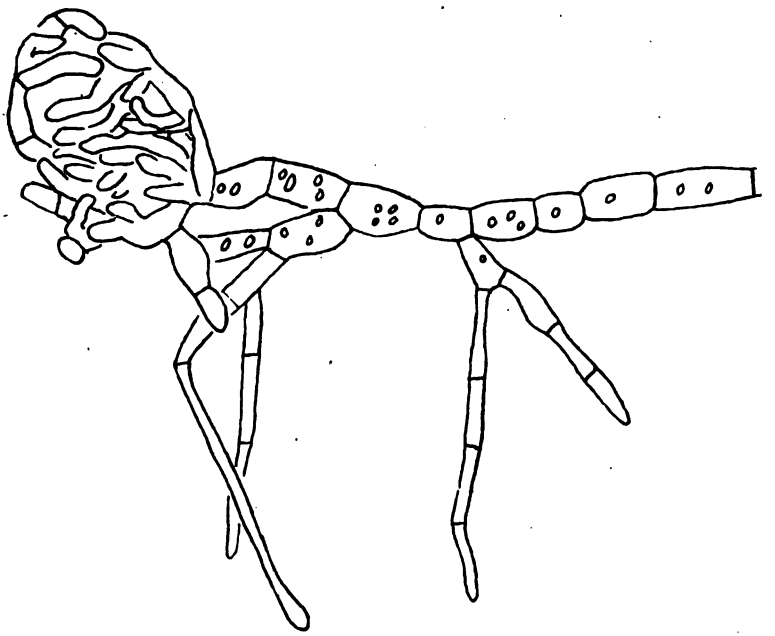

FIG. 14.—Single branch, near tip of rhizomorphic strand, bearing a young perithecium (x 285).

The ascigerous fungus, however, was very different on this medium from its growth on the Irish potato. The mycelium extended out from the surface of the potato in long, compact rhizomorphic strands (Figs. 12 and 13). Perithecia were produced in these strands in abundance, being occasionally produced on single short branches (Fig. 14). Small continuous or 1-septate conidia were also produced in abundance on short fertile hyphæ (Figs. 15 and 16). Considered alone, the habit on this medium would place the conidial stage of Neocosmospora in the Stilbaceae.

To these points of difference as brought out in my own cultures I may add that Smith failed to secure inoculations when the ascigerous fungus was used, though the parasitism of the internal fungus has never been brought to question. His words are:

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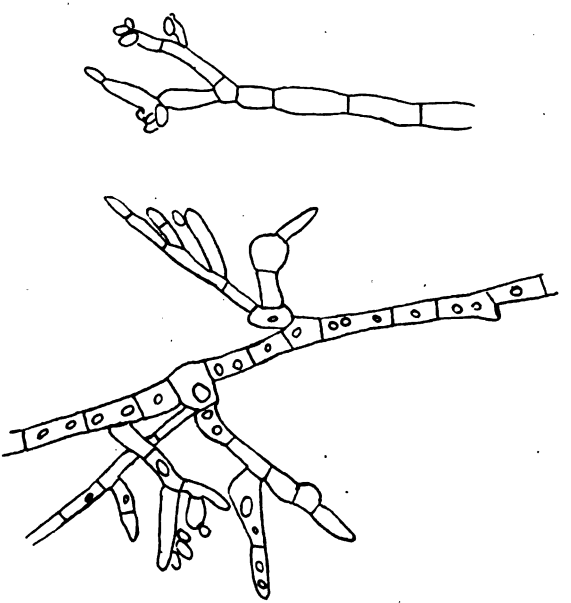
"Cowpea inoculations failed with the fungus derived from ascospores of the cowpea fungus. Nine large pots were used, but all of the 170 plants remained free from disease directly attributable to the *Neocosmospora*, although under observation for many months. These were soil inoculations, and an abundance of the fungus was used."



FIGS. 15 AND 16.—Fertile hyphæ from rhizomorphic strand bearing microconidia (x 385).

GENERAL DISCUSSION.

It will be noted that there are several general points of difference between the two fungi under discussion, and that these are maintained in all cultures. The following are the most prominent among these differences:

First. Perithecia are continuously produced in cultures of the ascigerous form, while they were never found in cultures of the internal fungus.

Second. There is a striking difference in the appearance of the mycelial growth of the two fungi. The internal fungus on all media produced a more aërial and more floccose white mycelium than the ascigerous fungus. The growth of the internal fungus on all media was more vigorous and rapid than that of the ascigerous fungus.

Third. Large sickle-shaped 3-5 septate conidia (macroconidia) were present in all cultures of the internal fungus. They have never been found in any cultures of the ascigerous fungus.

Fourth. Clamydospores are found in all old cultures of the internal fungus. They were never found in any culture of the ascigerous fungus.

Fifth. There seems to be no tendency whatever on the part of the ascigerous fungus to produce bright colors (yellow, red, pink, or purple) in any of the substrata employed. These colors are vivid where the internal fungus is grown on starchy substrata.

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These and other differences noted are made more comprehensive to the eye of the reader in the following tabulation:

ASCIGEROUS FUNGUS.	INTERNAL FUNGUS.
1. Perithecia always present.	1. Perithecia never present.
2. Growth slow.	2. Growth rapid.
3. Mycelium never pure white.	3. Mycelium on most media pure white.
4. Mycelial growth generally scanty.	4. Mycelial growth profuse on rich media.
5. Mycelium usually strict.	5. Mycelium aërial, floccose.
6. Macroconidia never found.	6. Macroconidia always found.
7. Clamydospores never found.	7. Clamydospores in all old cultures.
8. No bright color (red, yellow, pink, or purple) produced in any substrata.	8. Bright colors produced on starchy food (many shades of red and purple in rice, yellow to pink in potato, and pink in gelatine).
9. No yellow spore clusters appeared.	9. Yellow spore clusters on agar, potato, and stems of cured cowpea hay.
10. No growth below surface of gelatine.	10. Growth produced below surface of gelatine.

While these differences do not prove conclusively that the internal fungus and the *Neocosmospora* studied are not simply different strains of the same fungus, yet it would seem that these, with the other evidence presented, are sufficient to at least balance any evidence which I have been able to find to the contrary and to reopen this question, which has been regarded as closed.

The evidence for and against this question may be comprehensively summarized as follows:

Indications that the internal fungus and Neocosmospora are genetically connected.	*Indications that the internal fungus and Neocosmospora are not genetically connected.*
1. Perithecia of *Neocosmospora* are found on stem and roots of plants killed by the internal fungus.	1. Perithecia are found very rarely on such plants.
2. When grown in cultures *Neocosmospora* produces conidia very similar to the microconidia of the internal fungus.	2. Perithecia of many other ascigerous fungi are found on such stems.
	3. The perithecial stage of *Neocosmospora* has never been reported in connection with *Fusarium* wilts in other countries.
	4. *Neocosmospora* has not been observed to produce macroconidia. The internal *Fusarium* does.
	5. The internal fungus produces clamydospores. *Neocosmospora* does not.
	6. It has so far been impossible to change one fungous form into the other; *i. e.*, to stop permanently the production of peri-

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thecia by *Neocosmospora* or to obtain a perithecia-producing strain from the internal fungus.

7. The two fungi are very dissimilar in general appearance, in manner of growth, and in their reactions on various substrata, as shown in detail above.

SEXUALITY OF PERITHECIA.

In view of the interesting sexual relations shown in the Mucorales[1] it is of interest to note that single hyphæ of *Neocosmospora* can produce perithecia. Therefore, if the perithecia of *Neocosmospora* are the result of any sexual act at all, it must be simply between branches arising from the same hyphæ. That they do not arise from union of the two hyphæ of separate origin is shown in conditions such as that in Fig. 14.

CONCLUSION.

In the light of the above facts, it is unreasonable to conclude that the internal fungus (*Fusarium vasinfectum* Atk.) and *Neocosmospora* are genetically related. For the present and until evidence is found to the contrary, it seems best to regard the *Neocosmospora* as simply an accidental saprophyte, having no relation to the wilt of the cowpea or to the internal fungus, *Fusarium vasinfectum*, which is probably the true cause of the wilt.

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[1]Blakesley, A. F., Sexual Reproduction in the Mucorineae. Proc. Amer. Acad. Arts and Sci., 40, 4, 1904.

NOTE.—While the present article was in the hands of the printers my attention was called to an abstract in Annales Mycologici 8 April, 1910, p. 255-6, of an article by Dr. E. J. Butler, which upon different grounds sustains my own position regarding *Neocosmospora*. Dr. Butler worked with a wilt disease of chick-pea (*Cicer arietrium*). He found the perithecia of *Neocosmospora* on the dead vines, but considered it simply a soil parasite having no connection whatever with the *Fusarium* which caused the wilt. I have not yet seen his original article, so do not know exactly the evidence upon which his conclusion is based. B. B. H.

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THE SCUPPERNONG AS A PROFITABLE CROP—METHODS OF GROWING, KEEPING, AND WINE-MAKING—USED AT ITS PLACE OF ORIGIN.

By W. C. ETHERIDGE.

A large part of North Carolina, particularly the eastern sound-bordering counties, offers an opportunity to the farmers located therein for the development of a substantial industry which may be carried to advantage along with the usual farm operations of the locality, or taken singly and more extensively.

This is the growing for commercial purposes of Scuppernong grapes, to which the section is ideally adapted in soil and climate. With such natural advantages there is wonder that this industry remains undeveloped when the only other factor wanting is a market, the lack of which may be attributed more to an absence of enterprise in seeking than to its nonexistence, for undoubtedly with some effort and advertising a market could be found for the delicious light wine that may be produced from the Scuppernong grape. There are, to be sure, a few large vineyards in the State operated on a commercial basis by several wine companies of another State; but with the small farmer, to whom the Scuppernong might be made to yield as reliable revenue as his staple crops, the industry is dormant.

These grapes are very easily grown, requiring no other care than repairs to the scaffolding or trellis every few years and an occasional pruning; in fact, there is probably no other fruit that will thrive with the minimum of care and attention which is sufficient for the Scuppernong. The writer has in mind a very old vine which has received practically no care for over a hundred years, beyond repairs to the scaffolding, and yet it fruits vigorously.

The vines are always propagated from runners which may be had from any established vine by pulling or digging up the overhanging and rooted branches. These should be set out in the fall, and may be trained either on a scaffold or trellis, the former requiring less attention, while the latter affords easier access for pruning and gathering the fruit and gives the vine more fruit-bearing surface. If a scaffolding is used, the main posts should be of fat pine, if obtainable, as these will last indefinitely, although cypress and juniper make very good ones if the part that is to be buried is given a coating of tar. The running poles are best if of large cypress, or juniper saplings, 3 to 5 inches in diameter, stripped of their bark; yet any sort of pole or rail may be used for this purpose, as it may easily be replaced when rotten. If trellising is preferred, convenience may again be regarded in the selection of posts, as on account of their small size it is not difficult to replace them when needed.

When the vines are trained on a scaffold, pruning presents the only difficulty that occurs in their keeping, and this is obviated by the lack of actual necessity for it. By pulling the dead wood out of the vine once in several years it can be kept in fairly good condition. A trellised vine would, however, require more attentive pruning.

For making wine only ripe and perfectly sound grapes should be used. When fully ripe they are shaken into large sheets of burlap, or cloth, spread underneath the vine, the shaking being easily accomplished by jarring the

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vine with a pole crotched at one end by which a hold is obtained on the vine. Such trash from the vine, leaves and broken bits of stems or twigs, as may have fallen into the sheet is carefully picked out and the grapes are ready for the press.

The process is very simple, being only a flat, shallow trough about 8 feet long, 3½ feet wide at one end, tapering down to about 18 inches at the other, and having fixed at about 30 inches from the wider end a wooden roller 6 or 8 inches in diameter. This roller is covered spirally with strips of leather which give it a better catch on the grapes and make it less liable to smash the seed than if its surface were bare. To either or both ends is fitted a crank for turning. When in use, the trough is fixed between four posts at a convenient height for pouring in the grapes and is slightly inclined for the flow of the juice. The grapes are poured into the trough behind the roller, and it is slowly turned over them, crushing out the juice, which is received into a pail or tub placed beneath the lower end of the trough and is then strained into stands usually made by sawing a good oaken barrel through the middle. The juice is afterward filtered through some material that will catch the smaller rags of pulp and broken bits of seed which have escaped the strainer. A filter commonly used in the eastern part of the State is made of small pieces of sea-shells wrapped or mixed with clean, bright broom-grass and placed in a large funnel. This is very effective in clearing the juice.

After filtering, the juice is transferred to barrels, where it may be sweetened at once or after fermentation, this depending upon the quality of wine desired. If the sweetening is done before the juice ferments the wine retains much of the mild, natural flavor of the ripe fruit, but does not have the body, or "tang," that results if fermentation is first allowed. The amount of sugar to be used in sweetening is between two and three pounds per gallon of juice, and varies with the time the wine is to be kept: if it is intended for use within a year or two, less sugar is required than if the wine is to be aged; and less is needed if the sweetening is done before than after fermentation. After the juice is in the barrels the bungs are left out until all the fermentative gases have escaped, and are then driven tightly in.

Converting the fruit into wine is easily the most profitable disposal that can be made of it, provided a market can be found. A bushel of grapes will yield, even with the present crude methods of pressing, three gallons of wine, exclusive of the sugar added in sweetening. This should sell for at least $2 per gallon, making a gross return of $6 per bushel for the grapes. The cost of making the wine is small, as the method is a simple and easy one, requiring little skill and no apparatus that may not be provided at home. The only material entering into the process that need call for a direct expenditure is the sugar used in sweetening, and even this is used at a profit, as it increases the volume of the wine in about the same proportion as its own volume, the value of the extra quality of wine produced exceeding the cost of the sugar.

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II.—STUDIES IN SOIL BACTERIOLOGY[1]—AMMONIFICATION IN SOILS AND IN SOLUTIONS.

By F. L. STEVENS and W. A. WITHERS, assisted by J. C. TEMPLE and W. A. SYME.

In an earlier article[2] we called attention to the fact that inoculation of soils into solutions gives no adequate criterion of the nitrifying powers of soils, owing to the fact that some nitrifying soils fail entirely to nitrify in solutions, and that when in other cases nitrification occurs to some extent in each medium, the amount of nitrification in solutions is not commensurate with the amount of nitrification by the same soils, as soils. The question naturally arises whether a similar condition does not exist regarding the process of ammonification.

Ammonification for the present purpose may be defined as the conversion of organic nitrogen into ammonical nitrogen. It is probably the most important of all the nitrogen transformations, and accurate knowledge of the conditions which favor it is of permanent importance.

The studies of ammonification which have been made—and they are very numerous and important—have been conducted by isolating organisms and studying the chemical transformations induced by such pure cultures in solutions of artificial composition, or by throwing, in various ways, complexes of species in the form of small amounts of soils, or of suspensions derived from soils, into solutions for the purpose of study.

In view of the importance of the subject and in view of the doubts cast upon the validity of results arrived at by present methods of studying ammonification, a series of experiments was undertaken to ascertain whether reliable conclusions regarding the ammonifying power of a soil can be had by study of its effects when inoculated into solutions.

The bacteriological methods used were similar to those described in the earlier paper mentioned above, with exception as to the form of nitrogen used,[3] and may be so understood unless special description is given.

CHEMICAL METHODS.

To 400 grams of soil were added 10 cc. of chloroform and water sufficient, with that already present in the soil, to make 1,200 cubic centimeters, and the mixture shaken for one hour. After settling somewhat, the solution was filtered through a Pasteur-Chamberland filter. An aliquot part was taken. Nitrogen in the form of ammonia was liberated by magnesium oxide, caught in a standard acid solution and titrated with a standard alkali solution.

When the amount of ammonia was very small it was nesselrized instead of being titrated.

The amounts are expressed in terms of nitrogen.

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[1]Published in Centbl. Bakt. (etc.), 2 Abt., 23 (1909), Nos. 21-25, pp. 776-785.

[2]Stevens and Withers, studies in soil bacteriology—Nitrification in soils and in solutions. (Thirty-first Rpt. N. C. Expt. Sta., pp. 40-63) and Centbl. Bakt. (etc.), 2 Abt., 23 (1909), Nos. 10-13, pp. 355-373.

[3]Stevens and Withers, lc.

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EXPERIMENTS.

Experiment 62 was designed to test the relative rapidity of ammonification in soils as compared with solutions. Two hundred and forty milligrams of nitrogen as peptone, asparagin, and cotton-seed meal respectively were on December 12, 1907, placed in 500 cc. Erlenmeyer flasks, 400 cc. of tap water was added to each and the whole autoclaved at 115° for 15 minutes, then inoculated with 1 cc. of soil suspension from experiment 32[2] and allowed to stand nine days.

Two hundred and forty milligrams of nitrogen as peptone, asparagin, and cotton-seed meal respectively were also mixed with 400 grams of soil 1866. The mixture was autoclaved as above and inoculated with 10 cc. of soil suspension from experiment 32 in such a way as to be about two-thirds saturated after inoculation, and then allowed to stand twelve days. Analyses at the end of the period gave results indicated in Table I.

TABLE I.—SHOWING A DIFFERENT INTENSITY OF AMMONIFICATION IN SOILS AND IN SOLUTIONS.

	CONDITIONS.					RESULTS.	
			Inoculum.			Ammoniacal Nitrogen Recovered.	
Sample Number.	Time of Incubation—Days.	Medium—Kind.	Kind.	Quantity in cc.	Form of Initial Nitrogen.	Per Cent.	Mgs. per 100 cc. Solution.
1938	9	Water	Soil	1	Peptone	72.5[4]	43.5
1939	9	Water	Suspension from Experiment 32	1	Asparagin	100.0	60.0
1940	9	Water	Suspension from Experiment 32	1	C. S. M.[5]	36.5	21.9
1955	12	(Sterile soil 1866.)	Suspension from Experiment 32	10	Peptone	26.6	106.4
1956	12	(Sterile soil 1866.)	Suspension from Experiment 32	10	Asparagin	32.9	135.6
1957	12	(Sterile soil 1866.)	Suspension from Experiment 32	10	C. S. M.	23.1	92.4

It is seen here that though the soil culture received ten times as large an inoculum, *i. e.*, ten times as many bacteria, and stood three days longer, the ammonia produced in it from peptone was 36 per cent of that produced in solution, 33 per cent in the case of asparagin, and 65 per cent in the case of cotton-seed meal.

While the experiment does not admit of definite conclusions, because of the lack of parallelism in duration of the experiment and amount of inoculum, it certainly indicates very strongly that there is a great difference in the ammonifying power of this soil under the two conditions, *i. e.*, (1) when inoculated into solution, (2) when inoculated into soil itself.

[3]Stevens and Withers, lc.
[4]The ammonia originally present was determined and found to be of negligible quantity.
[5]C. S. M. signifies cotton-seed meal.

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Experiment 63 was begun on December 7, 1907, precisely as experiment 62, except that the inoculum was greenhouse soil 1866.

The results are shown in Table II.

TABLE II.—SHOWING A DIFFERENT INTENSITY OF AMMONIFICATION IN SOILS AND IN SOLUTIONS.

	Conditions.				Results.	
					Ammoniacal Nitrogen Recovered.	
Sample Number.	Time of Incubation—Days.	Medium—Kind.	Inoculum—Quantity in Grams.	Form of Initial Nitrogen.	Per Cent.	Milligrams per 100 cc. Solution.
1941	9	Water	1	Peptone	79.1[6]	47.5
1942	9	Water	1	Asparagin	78.1	46.9
1943	9	Water	1	Cotton-seed meal	39.8	23.9
1958	12	Soil 1866	10	Peptone	22.4	86.9
1959	12	Soil 1866	10	Asparagin	28.7	114.8
1960	12	Soil 1866	10	Cotton-seed meal	17.5	70.0

[6]Original ammonia was of negligible amount.

Conditions similar to those found in the previous experiment are noted. Based upon the per cent of ammonia found, peptone and asparagin are ammonified much more vigorously in solutions than in soil cultures; cotton-seed meal likewise, but not with so marked a difference, there being 28 per cent, 36 per cent, 44 per cent, as much ammonia produced in soil as in solution with peptone, asparagin, cotton-seed meal respectively.

Experiment 88. One hundred and twenty milligrams of nitrogen as cotton-seed meal were weighed into 300 cc. Erlenmeyer flasks, 200 cc. of tap water added, and the whole sterilized.

One hundred and twenty milligrams of nitrogen as cotton-seed meal were also mixed with 200 grams of each soil to be tested, flasked, and sterilized.

One hundred grams of the soil to be tested were well shaken with 200 cc. of water and 1 cc. of the suspension was added to each flask of the solution. One cc. of the suspension was also added to 20 cc. of sterile water, mixed, and this diluted suspension was poured into the sterile soils in the flasks and thoroughly mixed. Soils 1667, 1867, 1783, 1784, 1931, and 2069 were tested in this manner, thereby bringing into 200 grams of solution the same number of organisms and the same species of organisms as were mixed with 200 grams of the soil culture. This arrangement also provided that the organisms in soil media were in soils of the same quality as the soils from which these organisms were derived (identically the same soil, except for sterilization). The cultures were incubated seven days and then analyzed.

The results are given in Table III.

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TABLE III.—COMPARING OF SIX DIFFERENT SOILS REGARDING AMMONIFICATION IN SOIL AND IN SOLUTION.

Sample Number.	Conditions.		Results.	
	Medium—Kind.	Inoculum—Suspension of Soil.	Ammoniacal Nitrogen Recovered.	
			Per Cent.	Milligrams per 100 cc. Solution.
2152	Solution	1667	18.2[7]	10.9
2153	Soil		9.1	18.2
2154	Solution	1867	34.3	20.6
2155	Soil		18.9	37.8
2156	Solution	1783	23.1	13.9
2157	Soil		14.7	29.4
2158	Solution	1784	37.1	22.3
2159	Soil		22.4	44.8
2160	Solution	1931	24.5	14.7
2161	Soil		18.9	37.8
2162	Solution	2069	24.5	14.7
2163	Soil		30.8	61.6

[7]Original ammonia was of negligible amount.

Here, again, considering the per cent of ammonia produced, there is a great difference in the intensity of ammonification in soils and in solutions. In five of the six samples of soil tested, ammonification was again greater in the solution than in the soil cultures, while in one instance ammonification was greater in the soil culture.

Not only is there a difference in rapidity and absolute quantity of ammonification, but the rank of the soils as ammonifiers is different according to whether their ammonifying powers are measured in soils or in solutions.

Compared in Soil Cultures, their Rank as Ammonifiers is:	Soil Number.	Compared in Solution their Rank is:
1	2069	3
2	1784	1
3	1867	2
4	1931	3
5	1783	5
6	1667	6

Experiment 82. To test relative ammonifying powers of various pure cultures in soil and in solution.

The tests above recited were made with soils, composites of bacterial species. It was deemed advisable to ascertain how far the conclusions indicated by these tests hold true when pure cultures of species are employed. To this end fifteen pure cultures of ammonifying organisms were obtained from the most

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promising sources by plating from soils, cow manure, horse manure, and from two labeled cultures from the laboratory stock, and all of these pure cultures were inoculated into broth.

On March 16, 1908, 120 milligrams of nitrogen as cotton-seed meal were weighed into each of sixteen 300 cc. Erlenmeyer flasks, and 200 cc. of tap water added. An equal amount of cotton-seed meal was mixed with 200 grams of soil in each of the sixteen flasks of the same size. All were autoclaved for one hour. Both soil and liquid media were inoculated with 1 cc. of broth culture. To inoculate the soil flasks, tubes with 20 cc. of sterile water were first inoculated with 1 cc. of the broth culture and this dilution poured upon the soil and mixed with it. Ammonia was determined at the end of the fourth day. The results are given in Table IV.

TABLE IV.—COMPARING AMMONIFICATION OF PURE CULTURES IN SOIL AND IN SOLUTION.

Sample Number.	Conditions.		Results.			
			Ammoniacal Nitrogen Recovered.			
	Medium—Kind.	Inoculum—Kind.	Per Cent.	Difference in Favor of Soil.	Mgs. per 100 cc. Solution.	Difference in Favor of Soil.
2077	Sterile soil 1867	Organism 1	12.6	—11.4	25.2	10.8
2078	Water		24.0		14.4	
2079	Sterile soil 1867	Organism 2	7.0	— 5.1	14.0	6.7
2080	Water		12.1		7.3	
2081	Sterile soil 1867	B. subtilis	25.2	14.2	50.4	43.8
2082	Water		11.0		6.6	
2083	Sterile soil 1867	Organism 4	1.4	1.4	2.8	2.8
2084	Water		0.0		0.0	
2085	Sterile soil 1867	Organism 5	37.2	17.6	74.4	62.6
2086	Water		19.6		11.8	
2087	Sterile soil 1867	Organism 6	23.8	5.1	47.6	36.4
2088	Water		18.7		11.2	
2089	Sterile soil 1867	B. mycoides	2.8	— 3.0	5.6	2.1
2090	Water		5.8		3.5	
2091	Sterile soil 1867	Organism 8	22.4	6.5	44.8	35.3
2092	Water		15.9		9.5	
2093	Sterile soil 1867	Organism 9	18.2	2.6	36.4	27.0
2094	Water		15.6		9.4	
2095	Sterile soil 1867	Organism 10	23.8	— 4.9	47.6	30.4
2096	Water		28.7		17.2	
2097	Sterile soil 1867	Organism 11	34.3	5.8	68.6	51.5
2098	Water		28.5		17.1	
2099	Sterile soil 1867	Organism 12	3.5	0.0	7.0	4.9
2100	Water		3.5		2.1	
2101	Sterile soil 1867	Organism 13	32.9	13.3	65.8	54.0
2102	Water		19.6		11.8	
2103	Sterile soil 1867	Organism 14	21.7	2.8	43.4	32.1
2104	Water		18.9		11.3	
2105	Sterile soil 1867	Organism 15	9.8	6.8	19.6	17.8
2106	Water		3.0		1.8	
2107	Sterile soil 1867	Soil susp. 1867	27.3	10.5	54.6	44.5
2108	Water		16.8		10.1	

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Here, basing on per cent of ammonia, ammonification was greater in soils than in solutions in the large majority of cases. In only four instances was ammonification greater in solution than in soils. Basing upon amount converted per cc. of solution, the ammonification was greater in the soil in every instance. Basing upon per cent converted, the rank in ammonifying power is as follows:

Rank Tested in Soils.	Soil Number.	Rank Tested in Solution.	Source of Organism.
1	2085	4	Horse manure.
2	2097	2	Horse manure.
3	2101	4	Soil.
4	2107	8	Cow manure.
5	2081	12	Soil.
6	2087	7	Cow manure.
6	2095	1	Manure.
8	2091	9	Soil.
9	2103	6	Soil.
10	2093	10	Soil.
11	2077	3	B.—subtilis culture.
12	2105	15	Soil.
13	2079	11	B.—mycoides culture.
14	2099	14	Horse manure.
15	2089	13	Cow manure.
16	2083	16	Cow manure.

Five species hold the same rank in soil and solution; two have changed one rank; two, two ranks; four, three ranks; one, five; one, six; and one, seven ranks; some assuming a higher rank in soils, others higher in solutions.

It is seen from the tabulation that not only is the absolute ammonifying power different in the two media, but also that the rank of the organisms as ammonifiers is greatly altered by the mode of test.[1]

Experiment 105. On May 25, 1908, to further test the same point, whether tests made in solutions are fair criteria by which to judge either the absolute or relative ammonifying power of soils, experiments 105, 200, and 201 were made. In these experiments 120 milligrams nitrogen as cotton-seed meal was used, with 200 grams medium and 1 cc. inoculum.

In these experiments the cultures were all made in duplicate and with checks. Four soils were used, and with each the ammonifying power was tested in three ways, as follows:

1. By inoculation of a suspension into a sterile mixture of cotton-seed meal and water (*i. e.*, solution condition).
2. By inoculation of a suspension into sterile soils.
3. By adding the nitrogenous material directly to the live soil.

The results are given in Table V and summarized in Table VI.

[1]While the analyses of all samples were not completed on the same day, the analyses of all cultures inoculated with the same soil were made at the same time. Therefore, while the actual rank of these cultures as ammonifiers is not given here, the general conclusion drawn is legitimate.

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TABLE V.—SHOWING AMMONIFICATION IN SOILS AND IN SOLUTIONS.

Sample Number.	Conditions. Time of Incubation—Days.	Medium—Kind.	Inoculum—Kind.	Results. Ammoniacal Nitrogen Recovered. Per Cent.	Net.	Mgs. per 100 cc. Solution.	Net.
2285	10	Water	Suspension of 1784	29.00		17.4	
2286	10	Water	Suspension of 1784	29.40		17.6	
Average				29.20	26.86	17.5	16.1
2287	10	Water		2.34		1.4	
2288	10	Sterile soil	Suspension of 1784	21.01		84.0	
2289	10	Sterile soil	Suspension of 1784	22.40		89.6	
Average				21.31	19.21	85.2	76.8
2290	10	Sterile soil		2.10		8.4	
2291	10	Live soil 1784		22.40		89.6	
2292	10	Live soil 1784		23.10		92.4	
Average				22.75	21.35	91.0	85.4
2293	10	Sterile soil 1784		1.40		5.6	
2294	10	Water	Suspension of 1667	26.20		15.7	
2295	10	Water	Suspension of 1667	27.10		16.3	
Average				26.65	24.31	16.0	14.6
2287	10	Water		2.34		1.4	
2296	10	Sterile soil 1784	Suspension of 1667	9.80		39.2	
2297	10	Sterile soil 1784	Suspension of 1667	12.60		50.4	
Average				11.20	11.20	44.8	44.8
2298	10	Sterile soil 1784		0.00		0.0	
2299	10	Live soil 1667		0.70		2.8	
2300	10	Live soil 1667		17.50		70.0	
Average				9.10	9.10	36.4	36.4
2301	10	Sterile soil 1667		0.00		0.0	
2372	4	C. S. M. + H_2O	Suspension 2069	11.20			
2373	4	C. S. M. + H_2O	Suspension 2069	9.10		6.1	
Average				10.15	8.98	0.7	5.4
2374	4	C. S. M. + H_2O		1.17			
2375	4	Sterile 1867	Suspension 2069	23.81			
2376	4	Sterile 1867	Suspension 2069	23.11		46.9	
Average				23.46	18.56	9.8	37.1
2377	4	Sterile 1867		4.90			
2378	7	Live 2069		32.21			
2379	7	Live 2069		30.11		72.0	
Average				31.16	27.66	8.1	63.9
2380	7	Sterile 2069		3.50			
2390	7	C. S. M. + H_2O	Suspension 2069	14.24			
2391	7	C. S. M. + H_2O	Suspension 2069	23.57		11.3	
Average				18.91	18.21	0.4	10.9
2392	7	C. S. M. + H_2O		0.70			
2393	7	Sterile 1867	Suspension 2069	28.01			
2394	7	Sterile 1867	Suspension 2069	24.51		52.5	
Average				26 26	23.46	5.6	46.9
2395	7	Sterile 1867		2.80			
2396	7	Live 2069		32.91			
2397	7	Live 2069		37.81		81.7	
Average				35.36	31.86	8.1	73.6
2380	4	Sterile 2069		3.50			
2363	4	C. S. M. + water	Soil suspension 1931	6.77			
2364	4	C. S. M. + water	Soil suspension 1931	9.10		4.8	
Average				7.94	7.24	0.5	4.3
2365	4	C. S. M. + water		0.70			
2366	4	Sterile soil 1867	Soil suspension 1931	25.21			
2367	4	Sterile soil 1867	Soil suspension 1931	23.81		45.0	
Average				24.51	17.51	10.0	35.0
2368	4	Sterile soil 1867		7.00			

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TABLE V—*Continued.*

Sample Number.	Conditions. Time of Incubation—Days.	Medium—Kind.	Inoculum—Kind.	Results. Ammoniacal Nitrogen Recovered. Per Cent.	Net.	Mgs. per 100 cc. Solution.	Net.
2369	4	Live soil 1931		24.51			
2370	4	Live soil 1931		26.60	23.46	54.7	50.2
Average				25.56		4.5	
2371	4	Sterile soil 1931		2.10			
2381	7	C. S. M. + water	Soil suspension 1931	4.43			
2382	7	C. S. M. + water	Soil suspension 1931	13.07	8.05	5.3	4.8
Average				8.75		0.5	
2383	7	C. S. M. + water		0.70			
2384	7	Sterile soil 1867	Soil suspension 1931	28.70			
2385	7	Sterile soil 1867	Soil suspension 1931	28.70	23.10	57.4	46.2
Average				28.70		11.2	
2386	7	Sterile soil 1867		5.60			
2387	7	Live soil 1931		24.50			
2388	7	Live soil 1931		22.41	22.06	50.2	47.2
Average				23.46		3.0	
2389	7	Sterile soil 1931		1.40			

TABLE VI.—SUMMARY OF ALL RESULTS GIVEN IN TABLE V.

Medium.	Soil Inoculum.	Days.	Net Nitrogen as Ammonia. Per Cent.	Days.	Net Nitrogen as Ammonia. Per Cent.
C. S. M. and H_2O	1931	4	7.24	7	8.05
Sterile soil 1867	1931	4	17.51	7	23.10
Live 1931		4	23.46	7	22.06
C. S. M. and H_2O	2069	4	8.98	7	18.21
Sterile 1867	2069	4	18.56	7	23.46
Live 2069		4	27.66		31.86
C. S. M. and H_2O	1784	10	26.86		
Sterile 1784	1784	10	19.21		
Live 1784		10	21.35		
C. S. M. and H_2O	1667	10	24.32		
Sterile 1784	1667	10	11.20		
Live 1867			9.10		

It is seen here that at the end of four days soils 1931 and 2069 ammonified most vigorously in natural condition, next in sterile soil plus suspension, and least in the watery suspension; Nos. 1784 and 1667 most in watery suspension. It appears, then, that some soils will give a maximum test of ammonifying power in the liquid medium, others in the soil medium; that the test made in the liquid is not a fair criterion of ammonifying power. Though the differences are not so great as is the case with the phenomenon of nitrification.

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they are sufficient to change the rank of soils in ammonifying power—as, for example, in the above case where soil 1931 ammonified more than three times as rapidly in soil as in solution, as did also soil 2069; while soil 1784 ammonified a trifle better in solution than in soil. It is apparent that a proper comparison of the actual field ammonifying power of these three soils could not be had by comparing their ammonifying power in solutions. It is to be noted, also, that in the original data from which these conclusions are drawn determinations were made in duplicate with control cultures, and for the most part with excellent agreement between duplicates.

Experiment 209. On August 20, 1908, an experiment similar to the preceding was also made with pure cultures of several laboratory species and of three "wild" forms, Nos. 5, 7, and 11, isolated from various sources.

To inoculate, 1 cc. of a 48-hour old broth culture was added to 20 cc. of sterile water and poured into the soil flask or into the liquid culture, all in strictly parallel manner. The results are presented in Table VII. The initial nitrogen present in the form of cotton-seed meal was 120 milligrams; incubation was for seven days.

As with the composite inoculations of the last experiment, some species are seen to ammonify more vigorously in solution, other species in soils.

Organism No. 5 produced less than 7 per cent as much ammonia in solution as in soil; *B. megatherium*, 32 per cent; *B. mycoides*, 19 per cent. While organism No. 7 produced only 42 per cent as much ammonia in soil as in solution, organism No. 11 gave 46 per cent.

Ranking the organisms according to their ammonifying power in solution, we have No. 7, No. 11, *subtilis*, *megatherium*, *mycoides*, No. 5; in soil, *subtilis*, *megatherium*, No. 11, No. 7, *mycoides*, No. 5.

Thus it is seen that neither the absolute nor the relative ammonifying power of these organisms for soil can be ascertained by testing them in solutions.

SUMMARY AND CONCLUSIONS.

1. Some bacterial soil complexes ammonify faster in solutions.
2. Some bacterial soil complexes ammonify faster in soils.
3. Some pure cultures of organisms ammonify faster in soils, others faster in solutions.
4. The rank of soils, bacterial soil complexes, or of pure cultures is different as measured in soils or in solutions.

The general conclusion stands out clearly, as it did regarding nitrification, that neither for soils nor pure cultures of organisms can the ammonifying power be adequately determined by testing in solutions; that not even the relative ammonifying power of two soils or two organisms can be determined with certainty by the method of testing in solutions. While there is not so great a discrepancy between results by the solution and the soil method with regard to ammonification as obtains regarding nitrification, still the difference is sufficient to necessitate using soil as the medium in which to test ammonifying powers in cases where any degree of accuracy is desired and to check all determinations by soil cultures.

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TABLE VII.—TEST OF PURE CULTURES FOR AMMONIFICATION IN SOIL AND IN SOLUTION.

Sample Number.	Conditions. Medium—Kind.	Amount in cc.	Inoculum—Kind.	Results. Ammoniacal Nitrogen Recovered. Per Cent. Found.	Per Cent. Average.	Excess in Favor of Soil.	Excess in Favor of Solution.	Milligrams Per cc. Solution. Found.	Milligrams Per cc. Average.	Excess in Favor of Soil.	Excess in Favor of Solution.
2437	Sterile 1867	200	B. subtilis	16.84	16.14	3.91		33.7	32.3	7.8	
2438		200		15.44				30.9			
2439	Water	60	B. subtilis	11.41	12.23			22.8	24.5		
2440		60		13.05				26.1			
2441	Sterile 1867	200	B. mycoides	8.42	7.72	6.22		16.8	15.4	12.4	
2442		200		7.02				14.0			
2443	Water	60	B. mycoides	0.52	1.50			1.0	3.0		
2444		60		2.48				5.0			
2445	Sterile 1867	200	B. megatherium	14.38	14.21	9.54		28.8	28.4	19.0	
2446		200		4.04				28.1			
2447	Water	60	B. megatherium	4.21	4.68			8.4	9.4		
2448		60		5.14				10.3			
2449	Sterile 1867	200	Organism No. 5	8.03	7.26	6.77		16.1	14.5	13.5	
2450		200		6.49				13.3			
2451	Water	60	Organism No. 5	0.37	0.49			0.7	1.0		
2452		60		0.61				1.2			
2453	Sterile 1867	200	Organism No. 7	11.16	10.85		14.87	22.3	21.7		29.7
2454		200		10.53				21.1			
2455	Water	60	Organism No. 7	25.27	25.72				51.4		
2456		60		26.16							
2457	Sterile 1867	200	Organism No. 11	12.63	11.56		13.15	25.3	23.1		26.3
2458		200		10.49				21.0			
2459	Water	60	Organism No. 11	24.28	24.71			48.6	49.4		
2460		60		25.13				50.3			

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III.—STUDIES IN SOIL BACTERIOLOGY—CONCERNING METHODS FOR DETERMINATION OF NITRIFYING AND AMMONIFYING POWERS OF SOILS.[1]

By F. L. STEVENS and W. A. WITHERS.[2]

Nitrate nitrogen is generally believed to be the most readily available and most valuable form of nitrogen for plants. If this view be true, even in part, means of measuring the ability of various soils to produce nitrate nitrogen, to nitrify, are desirable, since on the nitrifying power of the soil would depend to some extent, possibly to a large extent, its productivity. To determine nitrifying power; to recognize deficiencies in nitrifying power; to ascertain the cause of such deficiencies when they exist and to find means of correcting them, all require quantitative studies of this factor of soil fertility. To make quantitative determinations of nitrifying power that shall be of broad utility and general value, methods which may be regarded as standard must be devised and their trustworthiness recognized. The biological equilibrium in soils is one of utmost instability, and variations in methods are likely to lead to great discrepancies in results.[3] These facts have been constantly forced upon us during the investigations of the past few years and have led us to the consideration of the question of uniform methods in this regard, the results of which we herewith present.

NITRIFYING INDICES.

Three conditions to be recognized in considering the nitrifying ability of a soil are:

1. The nitrifying organisms present.
2. The physical and chemical fitness of the soil for the proper functioning of these organisms.
3. The nitrifying efficiency of the soil and the organisms existing in it.

NITRIFICATION INOCULATING POWER (N I P).

The first index may be called the Nitrification Inoculating Power, which may be abbreviated as N I P. It recognizes only the factor of the live organisms present, taking no account of the fitness or unfitness of the soil for their activity. It does not regard bacterial species, but merely the complex present in the soil at the time it is tested.

Theoretically, the N I P may be high in a soil in which, owing to adverse chemical or physical conditions, no nitrification really occurs. Theoretically, nitrifying bacteria may be present in goodly numbers in a soil possessing physical and chemical conditions favorable to rapid nitrification, yet no nitrate appear, owing to the presence of other species of bacteria or of substances which either inhibit the action of the nitrifiers or destroy the nitrate which

[1]Read at the North Carolina Academy of Science, May 1, 1909, Durham, N. C. Published in Cent. Bakt. 25, 1909, 64.

[2]Assisted by J. C. Temple, W. A. Syme, J. K. Plummer and P. L. Gainey.

[3]Stevens and Withers. I—Studies in Soil Bacteriology. Nitrification in Soils and in Solutions. (N. C. Expt. Sta. Rpt. 1907-1908, pp. 40-63.)

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they produce, so that nitrate does not appear as a final product. N I P considers only the efficiency of the organisms present to give nitrate as a final product under circumstances favorable to their growth.

NITRIFYING CAPACITY (N C).

The second index, fitness of the soil as regards factors other than its content of living things, *i. e.*, its capacity to support nitrification, provided proper organisms be present, may be designated as its Nitrifying Capacity, abbreviated as N C. N C regards only the nonliving factors. Theoretically, a soil may be of high N C, but still fail to nitrify owing to lack of proper organisms, *i. e.*, to lack of proper N I P. Theoretically, a soil may be of low N C, yet show high N I P. N C will on final analysis be found to depend upon physical conditions and chemical composition, including water content.

NITRIFYING EFFICIENCY (N E).

The third index may be designated as the nitrifying efficiency of the soil, abbreviated N E, which regards the efficiency of the soil as a whole to produce nitrates as a final product. N E may be low owing to lack of N I P or to lack of N C, or both. N E will be high if there be high N I P associated with high N C.

Proper determination of N E will show whether a given soil is in normal vigorous nitrifying condition; if such is not the case, determination of N C and N I P will show whether it is the bacterial or nonbacterial factors which are at fault, and may lead the way to correction of existing defects.

CONDITIONS FOR DETERMINING THESE INDICES.

To make each of these indices of the greatest value the determination must be made as nearly as possible under the conditions that normally obtain in the field. Field conditions are highly variable from season to season, even from hour to hour, and may never be twice exactly alike. They can therefore be only approximated.

Since the soil temperature is extremely variable, sometimes above, sometimes below the optimum for nitrification, it seems best to employ the optimum temperature as standard.

Since the water relation is of dominating importance,[1] the amount of water in the soil cultures should imitate the natural condition of the soil that is to be tested. If this soil be one that is normally saturated or under water, swampy, the cultures should provide these conditions. It is difficult to determine the degree of saturation which best imitates the condition of a normal well-drained field. During and shortly after rain it is saturated. It rapidly dries, and until another rain occurs is considerably below saturation. Since, however, the greater part of the nitrification that does occur must occur during a period approximating the water content, optimum for nitrification, it seems best to use, as nearly as is practicable, this degree of saturation for all soils, other than soils normally saturated as mentioned above.

[1] Stevens and Withers. I—Studies in Soil Bacteriology. Nitrification in Soils and in Solutions. Centbl. Bakt. II ab. XXIII, pp. 355–373.

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PRELIMINARY EXPERIMENTS.

Preliminary experiments were made to ascertain several facts of importance in deciding upon methods, such as the optimum water relation, the effects of different modes of aëration, etc., upon nitrification when soils constitute the medium. The results of these experiments are as follows:

Experiment 2. To determine thermal death point of nitrifying organisms in soil. Forty grams of soil 1867, which had shown nitrifying power, with nitrogen added as asparagin, were put in each of six large test tubes. A tube of this soil was kept in the water bath, which had a temperature of 35°, for ten minutes after the temperature of the soil in a tube under similar conditions had reached 35°. Other tubes were in the same way exposed to temperature of 40°, 45°, 50°, 55°, and 60°.

Six sterile flasks, each of 400 gs. of soil 1867, containing 240 mgs. of nitrogen as asparagin, were then inoculated with the 20 gs. of soil, one flask from each of the tubes, and allowed to stand four weeks, when the nitrate present was determined.

The nitrification resulting was as follows:

Soil heated to 35° contained 27.36 per cent of N as nitrates.
Soil heated to 40° contained 30.28 per cent of N as nitrates.
Soil heated to 45° contained 35.24 per cent of N as nitrates.
Soil heated to 50° contained 38.16 per cent of N as nitrates.
Soil heated to 55° contained 24.28 per cent of N as nitrates.
Soil heated to 60° contained 00.00[1] per cent of N as nitrates.
Check, not inoculated, 000[1] per cent of N as nitrates.
Check, not inoculated, 000[1] per cent of N as nitrates.

It is seen that the thermal death point lay between 55° and 60°, a conclusion in accord with previously reported results.[2]

Experiment 76. To determine the influence of access of air. Two sets of cultures were made and incubated for four weeks beginning February 27, 1908, one with flasks cotton plugged in the usual manner, one with flasks hermetically sealed. Medium was live soil 1867 and 240 mgs. of nitrogen and cotton-seed meal.

The results are given in Table I.

[1]Nitrites and nitrates were tested for with diphenylamine solution. In case there was a coloration after one or two minutes, the amount of nitrites and nitrates was determined by the Teimann-Schulze method. If only a faint coloration appeared, which disappeared upon shaking, a trace was reported; and if no coloration at all appeared, the amount of nitrites and nitrates was recorded as zero. The test was made as follows (Treadwell-Hall Anal. Chem., 1906, Vol. 1, page 340):

"The reagent is prepared by dissolving 0.5 gms. of diphenylamine in 100 cc. of pure concentrated sulphuric acid and adding 20 cc. of water. A few cubic centimeters of the diphenylamine solution are placed in a test tube and carefully covered with the solution to be tested for nitric acid. If the latter is present, there is formed at the zone of contact between the two liquids a ring of beautiful blue color."

Treadwell states that "if one cc. of an acid (concentrated sulphuric S. and W.) which contains only one-twentieth milligram of nitrogen in a liter is used, the reaction will cause a noticeable coloration."

This test is less delicate in water solutions than in concentrated sulphuric acid. Wherever the amount of nitrites or nitrates is recorded in this article as zero small amounts may have been present and escaped detection.

[2]Lafar Technischen Mykologie, III.

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TABLE I—EXPERIMENT 76—EFFECT OF SEALING FLASK UPON NITRIFICATION.

Sample Number.	Condition of Aeration.	Per Cent of Initial Nitrogen Recovered as—		
		Ammonia.	Nitrite.	Nitrate.
2115	Sealed	35.71	0.00[1]	0.00[1]
2116	Sealed	23.11	0.00[1]	0.00[1]
2117	Not sealed	0.70	Trace	35.39
2118	Not sealed	0.00	Trace	25.99

The entire absence of nitrification in the sealed flasks quite precludes the use of such flasks in determining nitrifying indices, though for the purpose of avoiding evaporation sealed flasks would be desirable.

To ascertain whether the degree of compactness of the soil in the flask is of influence upon nitrification, cultures were set up with 400 gs. of live soil 1867+ 240 mgs. of nitrogen as cotton-seed meal or ammonium sulphate. The soil in two flasks was tightly compacted; in two others loosely sifted in; in two others the soil was removed and sifted twice weekly to give more complete aëration. Two other cultures were made in shallow dishes having an area each of 400 sq. cm. to give still more free aëration, but were covered with bell jars to prevent drying. Set up December 15, 1908. Analyses were made at the end of six weeks.

The results appear in Table II.

TABLE II—EXPERIMENT 60—TO ASCERTAIN THE EFFECT UPON NITRIFICATION OF DEGREE OF COMPACTNESS OF SOIL.

Number.	Condition of Experiment.		Results of Experiment.
	Condition of Soil.	Form of Nitrogen.	Per Cent of Nitrogen Found as Nitrate.
1991	Compact	Cotton-seed meal	62.6
1992	Compact	Ammonium sulphate	76.1
1993	Loose	Cotton-seed meal	63.6
1994	Loose	Ammonium sulphate	70.5
1995	Sifted	Cotton-seed meal	74.2
1996	Sifted	Ammonium sulphate	73.0
1997	In open dish	Cotton-seed meal	26.0
1998	In open dish	Ammonium sulphate	16.3

The first time this experiment was tried the sealed flasks broke from internal pressure; the second time, escape of gases was provided for by a water seal.

It is seen that with neither of these forms of nitrogen is the effect of the compactness of the soil, as shown in the first six flasks, of much influence upon nitrification under the conditions of the experiment. The low nitrification in the shallow dishes may have been caused by molds which developed to some extent in these cultures.

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Experiment 210. September 7, 1908. To determine whether the optimum degree of saturation for pure cultures is the optimum for the bacterial complex of soil 1867. Four-week cultures were made in sterile soil 1867+240 mgs. of nitrogen as ammonium sulphate, with different degrees of saturation, and inoculations were made with suspension from soil 1867 in some instances, with pure cultures of nitrifying organisms in other cases. The pure cultures consisted of a vigorous nitrite former and a vigorous nitrate former, isolated by the Stevens-Temple Silicate Jelly Plate.[1]

They were pure in the sense employed by Winogradsky in that they did not render bullion cloudy. They gave the following nitrogen changes:

TABLE III.

CULTURE OF	GAVE—
Nitrite organism in ammonium solution	Nitrite.
Nitrate organisms in ammonium solution	No nitrate and no nitrite.
Nitrate organisms in nitrite solution	Formed nitrate.
Nitrite organisms in nitrate solution	No denitrification.
Nitrate organisms in nitrate solution	No denitrification.

The results of Experiment 210 are given in table below.

TABLE IV—EXPERIMENT 210, SHOWING THE OPTIMUM DEGREE OF SATURATION OF SOIL 1867.

Number.	CONDITIONS.			RESULTS.		
				Percentage of Initial Nitrogen Recovered as—		
	Degree of	Inoculum—Kind.	Amount.	Ammonia.	Nitrite.	Nitrate.
2606	One-third	Nitrite + nitrate organisms	1 cc. each	45.51	0.15	12.53
2607	One-third	Nitrite + nitrate organisms	1 cc. each	46.35	0.38	11.06
Average				45.93	0.26	11.78
2608	Two-thirds	Nitrite + nitrate organisms	1 cc. each	38.51	1.87	13.16
2609	Two-thirds	Nitrite + nitrate organisms	1 cc. each	39.21	1.87	12.50
Average				38.81	1.87	12.83
2610	Complete	Nitrite + nitrate organisms	1 cc. each	44.11	0.07	0.00
2611	Complete	Nitrite + nitrate organisms	1 cc. each	44.74	trace	0.00
Average				44.47	0.04	0.00
2612	One-third	Susp. soil 1867	10 cc.	51.81	0.13	20.98
2613	One-third	Susp. soil 1867	10 cc.	54.61	0.12	17.54
Average				53.21	0.13	19.26
2614	Two-thirds	Susp. soil 1867	10 cc.	56.02	0.10	12.84
2615	Two-thirds	Susp. soil 1867	10 cc.	55.45	0.08	12.62
Average				55.73	0.09	12.73
2616	Complete	Susp. soil 1867	10 cc.	63.02	trace	0.00
2617	Complete	Susp. soil 1867	10 cc.	broken	trace	trace
Average				63.02	trace	0.00

[1]Stevens and Temple, "A convenient mode of preparing silicate jelly." (Centbl. Bakt., Sp. II, XXI, 1908, p. 84.)

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It is seen that the optimum for the pure culture differs from that of the soil 1867 and that no appreciable nitrification occurred under conditions of saturation with either inoculum.

Experiment 240. To determine the optimum degree of saturation of soil 1931 and the effects of slight variation in water content. 400 gs. of sterile soil 1931+240 mgs. of nitrogen as ammonium sulphate were inoculated with 10 cc. of suspension of soil 1867. Flasks were set up in duplicate carrying water to give 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, and 75 per cent of saturation. The results are presented in Table V.[1]

TABLE V—EXPERIMENT NO. 240, SHOWING THE OPTIMUM DEGREE OF SATURATION OF SOIL 1931.

Number.	Conditions. Water Added.		Results. Percentage of Initial Nitrogen Recovered as—		
	CC.	Per Cent of Saturation.	Nitrites.	Nitrates.	Nitrites and Nitrates.
3128	48	25	0.45	2.68	3.13
3129	48	25	0.52	4.18	4.70
Average	48	25	0.49	3.43	3.92
3130	--	--	trace	1.00	1.00
Net	--	--	0.49	3.43	2.92
3131	58	30	0.75	5.51	6.26
3132	58	30	0.45	8.32	8.77
Average	58	30	0.60	6.92	7.52
3130	--	--	trace	1.00	1.00
Net	--	--	0.60	5.92	6.52
3134	67	35	1.50	8.53	10.03
3135	67	35	0.60	12.44	13.04
Average	67	35	1.05	10.49	11.54
3130	--	--	trace	1.00	1.00
Net	--	--	1.05	9.49	10.54
3136	77	40	1.00	18.40	19.40
3137	77	40	0.75	18.04	18.79
Average	77	40	0.88	18.22	19.10
3130	--	--	trace	1.00	1.00
Net	--	--	0.88	17.22	18.10
3138	86	45	1.35	23.39	24.74
3139	86	45	1.35	26.21	27.56
Average	86	45	1.35	24.80	26.15
3130	--	--	trace	1.00	1.00
Net	--	--	1.35	23.80	25.15
3140	96	50	1.20	27.62	28.82
3141	96	50	0.45	27.74	28.19
Average	96	50	0.83	27.68	28.52
3130	--	--	trace	1.00	1.00
Net	--	--	0.83	26.68	27.52
3142	106	55	0.45	28.99	29.44
3243	106	55	0.45	29.62	30.07
Average	106	55	0.45	29.31	29.76
3130	--	--	trace	1.00	1.00
Net	--	--	0.45	28.31	28.76
3144	115	60	1.20	36.28	37.58
3145	115	60	1.45	38.64	40.09
Average	115	60	1.33	37.51	38.84
3130	--	--	trace	1.00	1.00
Net	--	--	1.33	41.51	37.84

[1]Slight corrections have been made in this table since its original publication in the *Centralblatt fur Bakteriologie*, etc.

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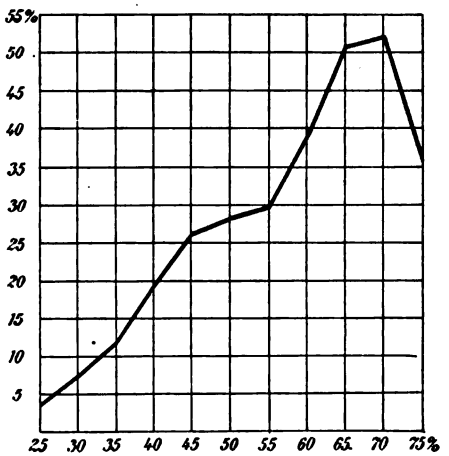
TABLE V—*Continued.*

Number.	Conditions. Water Added.		Results. Percentage of Initial Nitrogen Recovered as—		
	CC.	Per Cent of Saturation.	Nitrites.	Nitrates.	Nitrites and Nitrates.
3146	125	65	0.30	49.81	50.11
3147	125	65	0.30	51.06	51.36
Average	125	65	0.30	50.44	50.74
3130	---	--	trace	1.00	1.00
Net	---	--	0.30	49.44	49.74
3148	134	70	0.30	52.94	53.24
3149	134	70	trace	51.36	51.36
Average	134	70	0.15	52.15	52.30
3130	---	--	trace	1.00	1.00
Net	---	--	0.15	51.15	51.30
3150	144	75	0.30	36.66	36.96
3151	144	75	0.38	34.71	35.09
Average	144	75	0.34	35.69	36.03
3130	---	--	trace	1.00	1.00
Net	---	--	0.34	34.69	35.03

These facts are presented graphically in the following curve. It is seen that there is a gradual increase in nitrification with the increase in water content up to 70 per cent of saturation, and that beyond that point nitrification falls off rapidly with increase in water content.



Curve of nitrification at different degree of soil saturation. 1 cm. on the ordinate=5 per cent of initial nitrogen converted into nitrite or nitrate nitrogen. 1 cm. on the abscissa=5 per cent of saturation.

Experiment 211. September 10, 1908. To determine whether the degree of saturation that is optimum for one soil is optimum for others. Three sterile soils of very different saturation capacity were taken; 400 gms. of each were mixed with 240 mgs. of nitrogen as ammonium sulphate, inoculated with 10 cc. of suspension of soil 1867, and incubated four weeks.

The results are given in Table VI.

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TABLE VI—EXPERIMENT 211—TO ASCERTAIN WHETHER THE DEGREE OF SATURATION THAT IS OPTIMUM FOR NITRIFICATION IN ONE SOIL IS OPTIMUM FOR OTHER SOILS.

Number.	CONDITION OF EXPERIMENT 211.			RESULTS OF ANALYSIS.		
		Water Added.		Percentage of Initial Nitrogen as—		
	Medium—Soil.	CC.	Degree of Saturation.	Ammonia.	Nitrite.	Nitrate.
2619	1549	30	One-third	41.31	0.43	13.57
2620	1549	30	One-third	39.91	0.83	14.10
Average	1549	30	One-third	40.61	0.63	13.83
2621	1549	60	Two-thirds	24.51	2.25	24.29
2622	1549	60	Two-thirds	24.09	3.37	26.08
Average	1549	60	Two-thirds	24.30	2.81	25.18
2623	1549	100	Three-thirds	50.41	0.10	0.00
2624	1549	100	Three-thirds	52.79	0.10	0.00
Average	1549	100	Three-thirds	51.60	0.10	0.00
2625	1783	48	One-third	25.21	0.90	23.49
2626	1783	48	One-third	28.01	1.80	21.94
Average	1783	48	One-third	26.61	1.35	22.21
2627	1783	100	Two-thirds	16.80	0.25	23.82
2628	1783	100	Two-thirds	22.41	0.37	22.86
Average	1783	100	Two-thirds	19.60	0.31	23.33
2629	1783	144	Three-thirds	63.02	0.10	0.00
2630	1783	144	Three-thirds	57.42	0.12	0.00
Average	1783	144	Three-thirds	60.22	0.11	0.00
2631	1931	60	One-third	35.01	0.23	44.79
2632	1931	60	One-third	26.01	0.23	46.67
Average	1931	60	One-third	30.51	0.23	45.73
2633	1931	120	Two-thirds			
2634	1931	120	Two-thirds	8.40	trace	82.00
Average	1931	120	Two-thirds			
2635	1931	180	Three-thirds	43.41	0.10	trace
2636	1931	180	Three-thirds	45.51	0.10	trace
Average	1931	180	Three-thirds	44.46	0.10	trace

In this case each soil did better in soil culture of two-thirds saturation than in either one-third or complete saturation, though the degree of effect of this factor varies with the different soils, soil 1783 giving results about equal at one-third and two-thirds saturation, while the two other soils show nearly 100 per cent better results at two-thirds than at one-third saturation.

TABLE VII—EXPERIMENT 202, SHOWING EFFECT OF SOIL, *i. e.*, N C, UPON NITRIFICATION.

Number.	CONDITIONS.	RESULTS.		
	Medium.	Percentage of Initial Nitrogen Recovered as—		
		Ammonia.	Nitrites.	Nitrates.
2398–9	Sterile 1867	15.41	trace	17.75
2400–1	Sterile 2250	31.86	trace	0.00
2402–3	Sterile 2404	63.72	trace	0.00

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From the last three experiments, considered together, we must conclude that for different soils or different inoculums there are different optima of saturation.

Experiment 202. To show the effect upon nitrification of soils with different N C, set up July 13, 1908. Incubated four weeks, mixed 400 gms. of soil with 240 mgs. nitrogen as ammonium sulphate. Inoculum 10cc. of suspension of soil 1867. The results are shown in Table VII.

It is here seen that the same inoculum failed to induce nitrification in two soils, though it brought about marked nitrification in the other soils, showing clearly the effect of the soil itself upon nitrification, *i. e.*, of the necessity of recognition of what we here term nitrifying capacity (N C).

Experiment 231. To determine whether with different inoculums different rank is given to soils as to their N C. Period four weeks, medium sterile soil 400 gs., nitrogen 240 mgs. as ammonium sulphate.

TABLE VIII—EXPERIMENT 231, SHOWING EFFECT UPON N C OF DIFFERENT INOCULUMS.

	CONDITIONS OF EXPERIMENT.			RESULTS.	
Number.	Began Experiment.	Medium Sterile Soil Number.	Inoculum Suspension of Soil.	Per Cent of Initial Nitrogen Recovered as Nitrites and Nitrates.	Rank in N C.
2949–'51	12– 3–08	1549	No. 1867	0.00	
2952–'4	12– 3–08	1783	No. 1867	0.00	
2955–'7	12– 3–08	1931	No. 1867	9.09	1
2958–'60	12– 3–08	2069	No. 1867	0.00	
2961–'3	12– 7–08	1549	Filter bed	5.10m	2
2964–'6	12– 7–08	1783	Filter bed	3.89m	3
2967–'9	12– 7–08	1931	Filter bed	12.85	1
2971–'2	12– 7–08	2069	Filter bed	0.60	4
2993–'5	12–14–08	1549	N. J. soil	0.00	
2996–'8	12–14–08	1783	N. J. soil	0.00	
2999–3001	12–14–08	1931	N. J. soil	0.00	
3002–'4	12–14–08	2069	N. J. soil	0.00	
3022–'4	12–21–08	1549	Wis. soil	0.00	
3025–'7	12–21–08	1783	Wis. soil	4.36m	2
3028–'30	12–21–08	1931	Wis. soil	6.58p	1
3031–'3	12–21–08	2069	Wis. soil	0.00	

m Signifies that the duplicate samples agreed well.
p Signifies that the duplicate samples did not agree well.

It is here seen that though soil 1931 gave the highest N C with each inoculum used, there is variation in N C as determined by the use of different inoculums, since soils 1549 and 1783 failed to nitrify when inoculated with suspension of 1867, though one of them nitrified when inoculated with the Wisconsin suspension and both when inoculated with the filter-bed suspension.

RESULTS OF PRELIMINARY TESTS OF N E AND OF N I P DETERMINED IN SOILS AND N I P DETERMINED IN SOLUTIONS.

THE SOILS TESTED.

The soil from Geneva was sent by H. A. Harding with the statement that it came from a field "which has been in grass for many years, having been

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plowed up and borne one crop of corn. The land is of fairly stiff clay and of course well supplied with organic matter."

The soil from New Jersey, supplied by Dr. Lipman, was a red shale "which had been neglected for many years, but which has received thorough cultivation for the last three years." The other was from "an area which has been receiving application of 10-20 tons of manure annually for more than fifteen years."

The soil from District of Columbia, supplied by Dr. Kellerman, was a very rich, black, sandy loam which was said to be of good nitrifying power. The soil from Michigan, supplied by Prof. W. S. Sayer, was a "black soil from a low plat, but well drained. It was used for celery last year and for potatoes this year after a heavy coat of barnyard manure."

The soil from Wisconsin is described by A. R. Whitson of the Wisconsin Experiment Station as follows: "From a field of clay loam soil of glacial drift origin in a limestone region. The subsoil is sandy at a depth of three to five feet. The surface drainage is fairly poor, underdrainage is good. The field has been in alfalfa perhaps three-fourths of the time the past twelve years. During that time it has had top dressings of manure at about fifteen to twenty loads to the acre every three years. It is Plat No. 8 as described in Prof. F. H. King's reports on field work in the annual reports of this Station, from the fourteenth to the twentieth. It has grown two or three other crops of corn and oats."

Two of these soils supplied by Dr. Stephen DeM. Gage were from the sewage filter beds Nos. 1 and 9 of Lawrence, Mass., "which were yielding a highly nitrified effluent."

The Georgia soil, supplied by Mr. J. C. Temple, was from a rich, sandy loam garden.

All of these soils were sent in response to a request for soils most promising as nitrifiers.

Experiments 218, 219, 221. Determination of N E and N I P.

These experiments were conducted after the manner already reported and are sufficiently explained by the accompanying summary.

TABLE IX—SUMMARY OF RESULTS OF EXPERIMENTS 218, 219, 221, SHOWING RELATION N E. N I P IN SOIL AND N I P IN SOLUTION.

Number.	Soil.	N E.	Rank.	N I P in Soil.	Rank.	N I P in Solution.	Rank.
1	Filter No. 1	32.4	5	12.5	4	5.0	4
2	Filter No. 9	56.0	4	25.8	2	10.7	1
3	Michigan	85.2	1	12.2	5	2.9	6
4	Wisconsin	77.4	2	15.5	3	6.0	3
5	New Jersey, H	4.6	6	54.0	1	4.4	5
6	New Jersey Red Shale	70.5	3	4.7	6	7.0	2
7	D. C.			8.1m		4.5	

Some of the above tests were made without checks and some without duplicates, and are therefore subject to slight though probably insignificant error.

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TABLE IXa—EXPERIMENT 230, SHOWING RELATION N E, N I P IN SOIL AND N I P IN SOLUTION.

Number.	Soil.	N E.	Rank.	N I P in Soil.	Rank.	N I P in Solution.	Rank.
1	Filter No. 9	37.6	7	49.6	2	12.9	1
2	New Jersey, H	38.3	6	0.00	5	0.00	6
3	Michigan	90.31	1	8.45	1	9.79	2
4	Wisconsin	67.34	3	4.56	3	1.62	3
5	New Jersey Red Shale	62.33	5	trace	4	trace	5
6	Geneva	65.78	4	0.00	6	1.62	3
7	Georgia No. 1	80.82	2	----------	----------	0.00	6

[1]These determinations were made in duplicate and with checks. Duplicates agreed well.

It is seen in the above summaries that not only does the ordinary solution test fail to give the true rank of the soils in nitrifying power (seen most clearly in the case of the Georgia soil), but that the soil test also fails to do so, indicating clearly that N C plays an important part in determining the N E, and that all that can be had by a soil or a solution test is merely an indication of the bacterial conditions, not a true measure of nitrifying power of the soil in its natural condition.

METHODS FOR STANDARD ANALYSIS.

In the light of these preliminary experiments and of results previously reported, we have formulated the following rules for determining the N E, N I P, and N C of soils. The results of some hundreds of determinations by these methods we shall present in the annual report of the Experiment Station at a later date.

DETERMINATION OF THE N E OF SOILS.

Screen the soil to be tested through a wire sieve, of 3-4 mm. mesh (opening), to remove stones, sticks and coarser matter and to make the soil of good condition to manipulate; then determine its saturation capacity. To do this, 50 grams of soil, present saturation of which is known, are placed on a porcelain plate in a carbon filter and a measured quantity of water, a little more than necessary to saturate the soil, is added, and the effluent is poured upon the soil and allowed to drain through again. This operation is repeated twice to insure complete saturation. The amount of water taken up by the soil is determined by measuring the final effluent and subtracting from the measured quantity originally employed. Allowance is made for water already in the soil.

Weigh five soil equal to 400 gs. of dry soil[1] into a 500 cc. Erlenmeyer flask; add 240 mgs. of nitrogen as sterilized ammonium sulphate solution, with proper precaution against the introduction of germs extraneous to the soil (*i. e.*, using sterile sieves, containers, ladles, washing the hands with nearly surgical care, etc.); add sterile water sufficient, together with that already in the soil, to make it closely approximate two-thirds saturation; plug loosely with cotton; incubate at 30 to 35 degrees for four weeks.

[1]Dried two hours at 110°.

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Set up in duplicate and with two control flasks, *i. e.*, 400 gs. of the same soil in the same conditions, but without added nitrogen. Make up water loss weekly in all flasks. Determine the amount of nitrite and nitrate present in each flask at the end of the incubation period and report in terms of the element nitrogen.[2]

Subtract the average of the nitrite and nitrate nitrogen found in the two control flasks to give the *net nitrite and nitrate nitrogen* produced by organisms in the soil in question.

Express the N E as a coefficient equal to the per cent of the original 240 mgs. of added nitrogen that is represented by the net nitrite and nitrate nitrogen found.

When determining the N E for soils normally saturated or immersed, test the soils saturated instead of two-thirds saturated.

DISCUSSION OF N E METHOD.

To strictly reflect field conditions, humidity should be that of the field. Field conditions are, however, variable and such nitrification as does occur takes place mainly at moisture nearly the optimum. We therefore adopt two-thirds saturation as a standard condition for normally drained agricultural soils, and of course a condition of complete saturation for all soils that are normally saturated. Since soils vary in their optimum moisture relation, it would be still better to use the optimum for each separate soil studied. This is, however, manifestly impossible except in case of exhaustive research upon special soils.

The temperature suggested is near the optimum for most nitrifying bacterial complexes and is adopted for substantially the reasons leading to the adoption of the optimum saturation.

The time, four weeks, nearly one-third of a crop-growing season, is ample to give easily measured results in cases of soils in good nitrifying condition. Very poor nitrifiers would give different records with longer time; but this would retard work greatly, probably without affecting conclusions materially.

Aëration is probably better in these test conditions than in the field, but probably not so different as to materially affect results. (See experiment 76.)

That some nitrate is formed in the soils that is not recovered in analysis is certain. This is the chief objection to the use of soils as a medium; but in view of the complete inadequacy of solutions as a medium, there is no escape from the dilemma, and soils must be used.

Experiment 315. To determine the power of water to extract added nitrates from the soil. For this purpose three samples of soil were taken, viz.: Nos. 1931, a sandy loam, 3553, a red clay, and 3705, a soil rich in organic matter which had been used for horticultural pot experiments. These soils yielded to water respectively 2.38, 0.92, and 3.72 mgs. nitrogen per 400 gs. of soil. Separate portions of 400 gs. of soil were taken, sodium nitrate was added in amounts which corresponded to various percentages of 240 mgs. nitrogen. The samples were shaken two hours with the usual amount of water and nitrates were determined in the water extracts. These amounts are expressed as follows. Deductions were made of the amounts extracted from the natural soils.

[2]Stevens and Withers. I—Studies in Soil Bacteriology. Centbl. Bakt. Abt. II, Bd. 23, 1909, p. 355.

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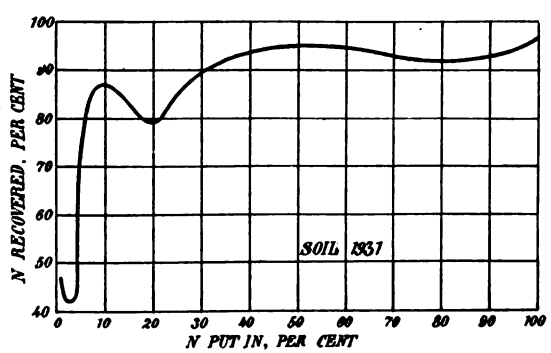
TABLE X—EXPERIMENT 315, TO DETERMINE THE ABILITY OF WATER TO EXTRACT ADDED NITRATES FROM THE SOIL.

Determined.	Nitrogen Added, Percentage of 240 Mgs.	Percentage of Nitrogen Recovered from Soil Number— 1931.	3553.	3705.
1	1.00	41.66	44.16	40.80
2	1.00	53.10	44.16	40.80
Average	1.00	47.38	44.16	40.80
1	3.00	41.66	42.20	40.00
2	3.00	41.66	42.20	40.00
Average	3.00	41.66	42.20	40.00
1	5.00	69.09	47.33	68.00
2	5.00	69.09	47.33	68.00
Average	5.00	69.09	47.33	68.00
1	10.00	87.70	47.00	87.70
2	10.00	84.50	47.00	81.40
Average	10.00	86.60	47.00	84.55
1	15.00	83.45	54.21	91.93
2	15.00	83.45	55.52	91.93
Average	15.00	83.45	54.87	91.93
1	20.00	79.85	62.65	93.95
2	20.00	78.30	64.20	93.95
Average	20.00	79.08	63.38	93.95
1	25.00	85.20	65.56	84.44
2	25.00	83.92	62.64	83.92
Average	25.00	84.56	64.10	84.18
1	50.00	96.46	68.90	90.20
2	50.00	93.96	70.16	89.58
Average	50.00	95.21	69.53	89.39
1	75.00	92.47	83.92	92.88
2	75.00	91.63	83.10	93.29
Average	75.00	92.05	83.51	93.09
1	100.00	97.09	85.19	95.21
2	100.00	97.40	84.56	94.59
Average	100.00	97.25	84.88	94.90

These tables show the recovery of only about 40 per cent nitrates when small quantities were added and more than twice this amount when large quantities were added. These results show that figures given elsewhere in this paper are not absolute; but as the percentage recovered increases fairly regularly, the incomplete recovery does not interfere with the conclusions, which have been drawn.

These facts are represented graphically in the following diagrams, which were drawn by L. L. Vaughan:



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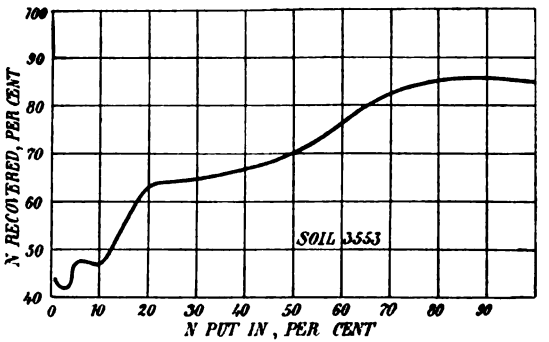

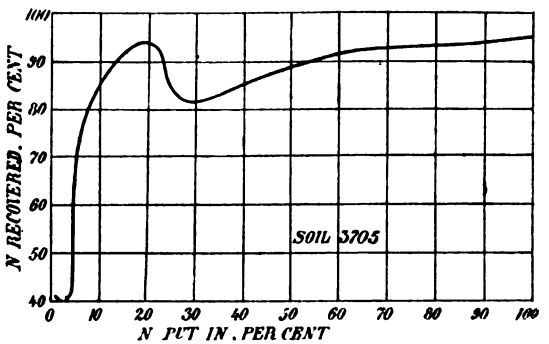

TO DETERMINE N I P OF SOILS.

Make a bacterial suspension from the soil to be tested, taking 100 gs. of soil to 200 gs. of sterile distilled water, shaking three minutes, sedimenting for five minutes, using the supernatant fluid. All work to be done aseptically. As a medium use the equivalent of 400 gs. of dry standard soil, sterilized, two-thirds saturated, with 240 mgs. of nitrogen added as ammonium sulphate. After inoculation with 75 cc. of the bacterial suspension from the soil to be tested, culture in Erlenmeyer flasks as for the determination of N E.

Do in duplicate and determine the nitrite and nitrate nitrogen present at end of four weeks. From the average of the two flasks subtract nitrite and nitrate nitrogen equal to that in the culture at the beginning, if any, to secure the *net nitrite* and *nitrate nitrogen produced*.

Express N I P as a coefficient equal to the per cent of original nitrogen changed to nitrite and nitrate nitrogen under these standard conditions in standard time. When determining N I P for soils normally saturated, use saturated cultures.

DISCUSSION OF N I P METHOD.

An artificial soil of high N C, which might be universally standard, is desired, but our attempts to construct such an artificial medium have failed utterly.

We recognize that with the use of a different standard soil somewhat different results would be had, but are convinced that the results had by the

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method here outlined approach the truth more nearly than earlier methods advocated and employed and give a near approximation to the truth. No one medium can reveal the whole truth.

The standard used by us is our soil 1931, which may be described as follows:

TABLE XI—STANDARD SOIL 1931—CLASSIFICATION, CECIL SANDY LOAM.[1]

Gravel over 2 mm. diameter, 2.72 per cent. Mechanical analysis of the fine particles shows the following:

	Diameter mm.	Per Cent.	
1	2–1	3.74	Fine gravel.
2	1–.5	9.91	Coarse sand.
3	.5–.25	9.42	Medium sand.
4	.25–.1	32.55	Fine sand.
5	.1–.05	13.52	Very fine sand.
6	.05–.005	22.07	Silt.
7	.005–.0	8.84	Clay.
Total		100.05	

A chemical analysis showed the soil to contain:

Moisture	7.03	per cent.
Humus	2.61	per cent.
Nitrogen total	0.082	per cent.
Nitrogen as nitrites	0.000	per cent.
Nitrogen as nitrates	0.0006	per cent.
Alkalinity in terms of $CaCO_3$	0.0074	per cent.
Phosphoric acid	Faint trace.	

TO DETERMINE N C OF SOILS.

The soil to be tested shall be prepared as for the determination of N E, then sterilized, inoculated, and subsequently treated as for the determination of the N I P; using the same inoculum at the same time in parallel cultures in standard soil. All cultures to be done in duplicate with controls.

The N C is expressed as a coefficient equal to the coefficient obtained by the soil to be tested, divided by the coefficient obtained by the standard soil.

If it were possible to maintain a standard inoculum, the N C could be directly determined, but means of maintaining such an inoculum have not yet been devised.

We recognize here that the use of a different inoculum would lead to somewhat different results, and that tests with no one inoculum can reveal the whole truth.

[1]The classification and mechanical analysis were made by G. M. MacNider, Assistant Chemist, N. C. Department of Agriculture.

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STANDARD METHOD REGARDING AMMONIFICATION.

For the same reason set forth regarding nitrification, we believe that the ends of soil bacteriology will be furthered by the adoption of similar indices regarding the soil factor of ammonification. We therefore propose the terms Ammonifying Efficiency (A E), Ammonifying Inoculating Power (A I P) and Ammonifying Capacity (A C), to be determined in the following ways:

To Determine A E.

The sample to be prepared and tested as for N E, with the exception that 200 gs. of soil be used and that nitrogen 120 mgs. be added as cotton-seed meal instead of as ammonium sulphate; incubation to be for seven days; analysis to be for ammonia.[1]

To Determine A I P.

The sample to be prepared and tested as for N I P, except that nitrogen be added as cotton-seed meal medium 200 gs. inoculum 25 cc. and that incubation be for seven days and analysis for ammonia.

To Determine A C.

The sample to be prepared and tested as for N C medium 200 gs., the inoculum to be 1 cc. of a pure culture of B. *Subtilis* twenty-four hours old in standard beef bouillon at incubator temperature, which culture was inoculated with one oese from another culture. This inoculum to be frequently standardized against standard soil and corrections made for any change from its original ammonifying power.

[1]For methods see Stevens and Withers, II—Studies in Soil Bacteriology. Centbl. Bakt. ab. II, Bd. 23, 1909, p. 776.

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[PRESS BULLETIN, No. 16, SEPTEMBER 1, 1908.]

SELECTING SEED CORN FOR LARGER YIELDS.

BY C. B. WILLIAMS, DIRECTOR.

The practice of selecting seed corn from the barn late in the spring costs the farmers of North Carolina, in decreased yields of shelled corn, an amount equal to more than five million dollars annually. Just so long as this method is followed, just so long will the corn growers of the State lack this amount of producing what they might with the same treatment under identical conditions were they to use better methods in the selection of their seed corn. The proper place to select seed for planting purposes next year is in the field this fall. One day spent in the field in selecting seed corn properly will pay better in increased yields than most any labor performed during the entire year. There are many ways in which this work might be done satisfactorily, the exact method depending upon local conditions and practices. Economy of performance of the operation is always to be looked after, but not at a sacrifice of efficiency. Where corn is gathered from stalks in the field in the usual way, a good method for the corn grower to use is to sling a cotton-picking bag over the shoulder or take a basket in the hand and go through and make the selections from the field of corn which he has that is a little above the average in productivity. Take two rows at a time and select seed from those stalks which have two well-developed ears per stalk, remembering that in the selection of seed one should select from the stalks that will yield the largest amount of shelled corn per stalk. The reason why it is advised selecting from two-eared stalks is because in testing and studying varieties of corn during the past eight years on the Experiment Station farm, and elsewhere, it has been found that the best yielders of shelled corn per stalk, and hence per acre, were those that averaged near two ears per stalk. Take both of the ears if they are good ones, and reject both if they are not. Do not give much detailed attention to the shape of the ears and grains during field selection, but reserve this for some rainy or snowy day during the winter and have the young boys around to help, as there is no form of farm work that will interest them more or lead them to take a deeper interest in the work of the farm. One reason why so many boys leave the farm is because they are not taught that there is something more in farming than the mere drudgery connected with it. When going through the field selecting these ears it might be well to have the boys along too, if they are old enough to appreciate the value and importance of what is being done. A cart or wagon might be at one end of the rows and when you get there each time empty the basket or bag. Enough corn should be gathered in this way so that when the more careful selection is made during the winter at the barn, having in mind the best shape of ears and kernels, enough will be left for planting, after throwing out the ears of poor shape and those having kernels not up to the proper type it is wished to use for planting. Select from the field three to five times as much corn as it is expected to be needed, so that a very rigid selection of the ears may be made during some winter day. Make selections from

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stalks that not only bear two well-developed ears, but from those that have a good leaf development and large root system. Select ears that are borne at a uniform and convenient height, for such ears are more easily and cheaply gathered, they ripen more uniformly, and are less liable not to have the embryo grains fertilized, as the tasselling of all stalks will be practically at the same date and the pollen from all will be given off at about the same time. The ears should be held not upright, but in a rather drooping position, as such ears are less liable to rot, as they will shed the rain rather than admit it into the ears, as they frequently do when held in an upright position; especially is this so if the husks (shucks) do not cover the tips of the ears completely. Also, it is well to discard all ears that have the tips poorly covered with husks, even if all the other characteristics are up to requirements. When, during the winter, the corn thus gathered is gotten out for more careful selection, choose those ears of cylindrical shape and those which possess deep wedge-shaped and large-germed grains which completely and deeply cover the cobs and which are arranged in parallel rows. Select heavy, well-matured ears that have medium-sized cobs with kernels that are heavy in weight and medium rough in indentation, and which have the butts and tips fairly well filled out. Keep the seed stored in a dry place until planting time.

If you have not selected your seed corn before from the field in the way indicated above, try it this fall. You may be a little doubtful of the value of this extra effort, but give it a fair trial and we feel sure that you will never go back to the old and less profitable method of selecting seed corn from the barn.

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[PRESS BULLETIN, No. 18, FEBRUARY 15, 1908.]

THE APPLE BITTER ROT.

BY F. L. STEVENS, BIOLOGIST.

Occurrence in North Carolina.—This disease occurs in very destructive form throughout the Piedmont and eastern sections of the State, though it is possibly less destructive further west. In a recent trip through the middle section of the State the writer saw dozens of orchards ruined by this rot which, but for the presence of it, would have yielded largely. In many of the orchards visited the trees were in fine condition, showing suitability of soil and climate, and they bore an abundance of fruit, but closer examination showed that the ground under the trees was completely covered with rotten apples and that the apples still on the trees had numerous specks of soft, brown rot. In many villages and towns all apples offered for sale in stores were affected with this rot.

The facts as stated above show the very destructive prevalence of this disease in this State.

This rot has been known in destructive form in the United States since 1867. It is estimated to have done $1,500,000 of damage in four counties in Illinois in 1900. In the Middle States the losses are estimated to be from one-half to three-fourths of the entire crop. The President of the National Apple Shippers' Association estimated the damage in the United States in 1900 at $10,000,000.

Description of the Bitter Rot.—There are many different types of apple rot—some are hard, some soft, some wet, some dry, some of one color and some another, etc. The bitter rot of the apple, sometimes called the ripe rot, is a soft, wet, yellow rot, occurring usually as circular spots on the fruit. These spots, of which there may be from one to twenty or more on each apple, enlarge rapidly, run together, and the whole fruit becomes a soft, rotten mass. The disease usually begins while the fruit is still hanging on the tree, and as the disease progresses, many of the apples fall to the ground below.

Cause of the Rot.—This rot is caused by a fungus, known as *Glœosporium*, the spores of which fall upon the apple, grow, penetrate it, and cause the decay. The spores are produced in immense quantities in small pustules, which appear upon the rotted surface. In many instances the fungus passes the winter in cankered spots on the twigs and bark.

Treatment.—There are two forms of treatment, both of which should be followed.

First, inasmuch as the fungus is known to winter in the canker on the branches, it is important when the leaves are off the trees to carefully inspect the orchard, hunt out these cankers, cut them out and burn them, and thus remove the most dangerous source of spring infection.

Second, the trees should be sprayed with Bordeaux Mixture in order to kill all spores which fall upon the fruit or twigs. Spraying should be applied before the buds begin to swell in the spring, just after the blossoms fall, and every ten or fourteen days thereafter until the fruit is almost ripe.

These two treatments combined will, to a very large extent, serve to control this very serious disease.

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[PRESS BULLETIN, No. 19, NOVEMBER, 1908.]

SUPPRESSION OF TERRAPIN BUGS.

(Also known as Fire Bugs, Calico Bugs, Harlequin Bugs, and Collard Bugs.)

BY R. I. SMITH, ENTOMOLOGIST.

SOME IMPORTANT FACTS.

As the remedial measures given below are based upon certain vulnerable points in the life-history of this insect, the following important facts are given:

1. Terrapin bugs hibernate during winter in the adult stage.
2. They may now be found on collard, turnip, cabbage, kale, and other cruciferous crops, as well as occasionally on other plants.
3. Terrapin bugs feed on the plant juices, obtained by means of a slender pointed beak. Hence they cannot be poisoned with arsenical sprays like Paris green.
4. Each individual may lay from ten to fifteen masses of twelve eggs each, or from one hundred and twenty to one hundred and fifty-six eggs. Occasionally a greater number are laid.
5. The period of egg-laying lasts about two months. In spring, the eggs require about eight to eleven days to hatch, but only three to four in hot weather.
6. THERE ARE ONLY THREE FULL BROODS ANNUALLY, but some bugs in all stages of development may occur in the fields as late as November.
7. THE BUGS WHICH BECOME ADULTS AFTER ABOUT SEPTEMBER 1 DO NOT LAY EGGS THE SAME FALL, but live over winter and produce the first spring brood.
8. Every adult female terrapin bug destroyed this fall might, if allowed to live, produce over one hundred bugs next spring.

WHY THE ABOVE FACTS ARE OF VALUE.

The above facts are pertinent, and some, especially NUMBERS 4, 6, AND 7, ARE NEW, and have been obtained by the writer as a result of a careful study of the terrapin bug—its habits and life-history—during the present year. This work shows quite conclusively that the farmer has a good opportunity to prevent a large part of the annual loss of thousands of dollars caused by the deterioration in the value of crops attacked by this destructive pest. The opportunity centers on the fact that all bugs maturing after about September 1 do not lay eggs the same season. If all adult bugs present during September, October, and November did lay eggs continuously, it would be a never-ending task to collect or to destroy them by spraying. The mature bugs are not easily killed by a contact spray like kerosene emulsion, although it will kill most of the young ones. Only a few eggs would be killed by spraying.

These facts are presented at this time in order to stimulate farmers and gardeners to fight the terrapin bugs NOW during the first days of November. It matters not whether the bugs are present in small or large numbers. It is certain that the bugs will have to be fought next spring and summer if they are not destroyed now; and just consider how much easier it is to catch and kill one terrapin bug at this time than it will be to wait and destroy her progeny next spring, numbering, perhaps, over one hundred.

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HOW TO DESTROY THE BUGS.

In the opinion of the writer, there are only two effective methods of destroying terrapin bugs: one being hand picking and death by crushing or dropping in kerosene, and the other the use of a contact spray like strong kerosene emulsion, that will kill all the bugs it can be made to touch.

Hand Picking.—Unless the bugs are very numerous, hand picking is the most practical remedy. Children may do the work as well and even faster than grown persons. The bugs may be collected quite rapidly by picking all in sight and then shaking the plants and collecting those that drop. This work should be done on warm, sunny days, when the bugs are not in hiding, and one should not expect to get all at the first picking. Go over the infested plants two or three times, and on different days. The results from one thorough picking will, however, fully repay the farmer for his time and cost.

In fields in which the infected crop is of no further value, the plants may be pulled and piled in small heaps and left a couple of days until the terrapin bugs congregate on them, when the bugs may be readily killed by burning or treatment with pure kerosene. Be sure that the bugs are destroyed before they migrate to other feeding grounds.

Spraying the Crop.—This method is of some value, but is not strongly recommended for use at this time of the year. Kerosene emulsion at 25 to 30 per cent strength will kill many bugs, if it can be applied so as to cover them thoroughly. It is recommended mainly, however, for killing the small or half-grown bugs during summer. Where bugs occur on worthless plants, pure kerosene may be used with good results so far as killing the bugs is concerned, but the expense will often be more than would be required by hand picking.

By following the directions given above, thousands of dollars will be saved annually to North Carolina farmers.

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[PRESS BULLETIN, NO. 20, FEBRUARY, 1909.]

SPRING DESTRUCTION OF TERRAPIN BUGS.

BY R. I. SMITH, ENTOMOLOGIST.

The annual loss caused by terrapin bugs sucking the life out of collards, cabbages, turnips, and allied plants is difficult to estimate accurately, but certainly amounts to thousands of dollars in North Carolina. A large proportion of this loss may be prevented if farmers, gardeners, and truckers will take the trouble to collect or in some way destroy the bugs that first appear this spring. We have conclusive evidence that such work may be made a paying investment. We cannot, however, continue to wait, as is usually done, until the bugs become so numerous as to cause very noticeable injury in gardens or fields, but on the contrary they must be destroyed before they commence to lay eggs; otherwise the annual loss will remain the same or will increase.

In November last this Station published a press bulletin urging farmers to immediately collect and kill the terrapin bugs, then in their fields, to prevent their living in such numbers through the winter. Now it seems advisable to urge the equally important work of destroying those individuals that escaped last fall, and which will soon commence to come out from their winter hiding quarters.

ONLY ADULT BUGS SURVIVE THE WINTER.

Eggs and young bugs do not live through the winter in this State; hence it is only full-grown, strong, adult males and females which survive by finding favorable hibernating quarters under rubbish around the gardens, under stones, in fence corners and similar places, where they are protected from the weather. As this has been a mild winter, they are liable to appear in greater numbers than usual in the spring.

WHEN EGG-LAYING COMMENCES.

We could not consistently urge the task of destroying the overwintering bugs if they commenced to lay eggs upon their first appearance. Careful observation has shown that at least two weeks' time elapses after the bugs appear before the first eggs are deposited. During this period they are very actively feeding and mating, and the majority will congregate on the few old plants left from last season's crop. Wild mustard and turnips are favorite food plants, and collards, with their broad leaves, often harbor a large number of them.

The prime object of this article is to emphasize the fact that the farmer or gardener who watches closely for the first terrapin bugs to appear has about two weeks' time to kill them and still prevent the majority from laying eggs for the first generation.

RATE OF INCREASE.

Have you ever considered the actual benefit that results from killing one female terrapin bug when she first appears in spring, Observe the following statements: The average number of eggs laid by each bug varies from eighty-

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four to ninety-six—that is, seven or eight masses of twelve eggs each, deposited over a period of from four to eight weeks. There are three full generations each year. Suppose we kill a single terrapin bug and thus prevent ninety-six young for the first generation, of which one-half might be females. If these forty-eight females reproduced at the same rate, the second generation would number 4,608 individuals. Counting only one-half as females, each capable of producing ninety-six young, the third generation would reach the enormous number of 221,184, the progeny of one female in a single year. We can divide this number by one hundred and still have over 2,200 as the number of bugs prevented by killing one individual when she first appears.

During the warm summer months a minute parasite in the form of a tiny black fly destroys a large percentage of the eggs, but as a general thing these parasites do not become abundant until the first generation is well developed; so that the destruction of the bugs that produce the first generation is more essential than the death of bugs later in the year. Another point in favor of early destruction.

Are not the above facts sufficient to impress farmers with the importance of spring destruction of terrapin bugs?

HOW TO DESTROY THEM.

Hand Picking.—This is probably the most valuable method of killing terrapin bugs at any season of the year. The work can be done rapidly by children. The bugs are inclined to hide on cold, windy, or dark days; so that warm, sunny days should be selected for this task. We cannot expect to find all the bugs in one day, or even the majority of them. A good plan would be to collect two or three times a week, but be certain to commence within a few days after the bugs first appear. They may be killed by crushing or by dropping in a little kerosene.

Spray with Pure Kerosene.—When the bugs are abundant on worthless plants they may be killed with pure kerosene. With the aid of a small spray pump a large number of bugs may be killed in a few hours.

Arsenical poisons are not effective against this insect, which feeds by sucking the plant juice.

Kerosene emulsion of 15 or 20 per cent concentration is used with success for killing small or half-grown bugs, but this treatment will not kill many adults. By following the suggestions made above, the young bugs will not become numerous, but whenever spraying does become necessary kerosene emulsion is the best remedy to use.

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BULLETIN 200 APRIL, 1909

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

WEST RALEIGH

FEEDING FERMENTED COTTON-SEED MEAL TO HOGS.

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N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

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A. R. RUSSELL.....Assistant in Field Experiments
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The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

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ORIGIN AND IMPORTANCE OF THE SCUPPERNONG AND OTHER MUSCADINE GRAPES.

By F. C. Reimer, Horticulturist.

One of the most important things connected with the introduction of a new fruit is a careful study of the conditions which surround the plant in its native home. In the planting of fruits during the past, often too little attention has been given to this matter. The home of a species usually indicates the locality or localities that it is best suited to. It determines in a large measure where that fruit can be grown and where it is likely to give best results. A species is more or less a product of the locality in which it originated, as the conditions prevailing there have in a large measure produced it. By natural selection, nature eliminates those forms not adapted to the environment.

This principle is well illustrated by our native fruits. The grapes of the eastern portion of the United States are far better suited to that section than any of the foreign species. This is also true of our native species of plums, blackberries, dewberries and raspberries.

The same principle applies particularly to varieties. A variety is usually best suited to the particular section in which it originated. The varieties of apples, peaches, pears and plums best suited to the Southern States are those which have originated in the South: for example, the Red June and Bonum apples, the Greensboro and Lady Ingold peaches, which originated in this State, reach their greatest perfection here.

The history and development of most of our important native fruits has been determined and recorded. Bailey and Munson have traced the development of our leading species of grapes, except *Vitis rotundifolia*—the Muscadine grape—on which practically nothing has been done. It is rather difficult to determine why this is true, as it is by far the most important species of grape in the South. The history of the different varieties of the Muscadine grape should be fully determined and preserved. This species has always been a very interesting one to North Carolinians, as it is native to the eastern half of the State, and most of the varieties have originated there.

HISTORY OF THE SCUPPERNONG.

Confusion Regarding Early History.—The following opinions have been offered regarding the origin of the Scuppernong: that it is a foreign variety introduced into this country many years ago; that it is a native of Virginia and was brought to North Carolina by the

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early settlers; and that it is a native of North Carolina. Of those who hold to the last belief, some claim Tyrrell County and others Roanoke Island as its original home.

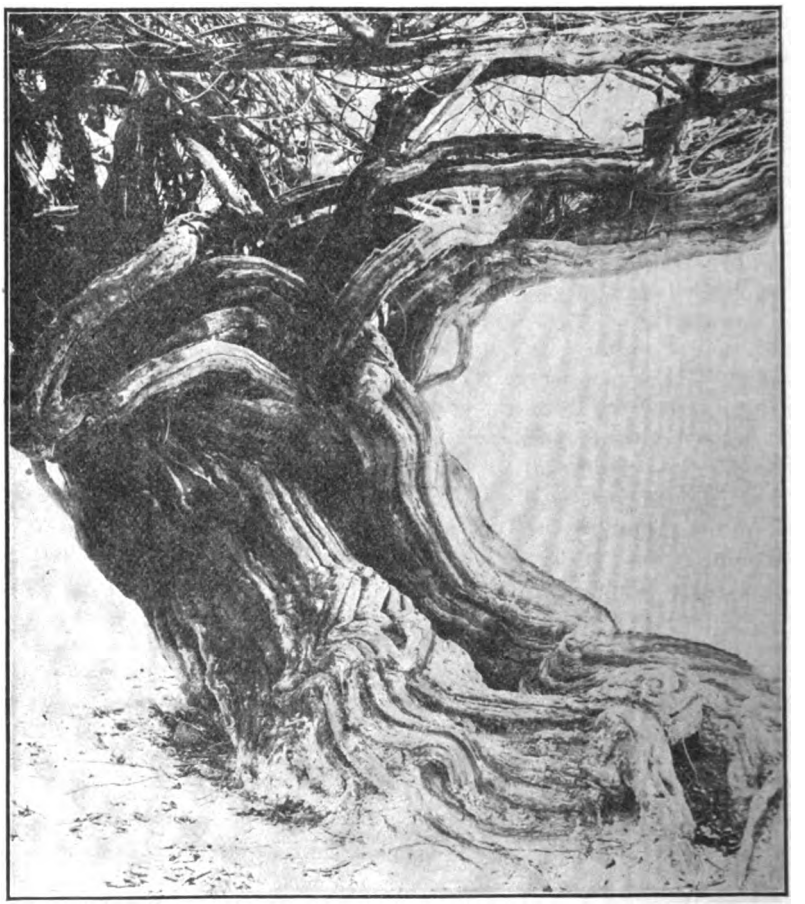

Fig. 1.—Characteristic Old Scuppernong Trunk.
(Circumference seven feet six inches.)

Although much has been written regarding this variety during the last half century, no one has indicated how and when the name "Scuppernong" was assigned to it. It is believed by some that this honor belongs to the North Carolina Indians; by others, that it belongs to the early white settlers. Some maintain that the name was taken from Scuppernong River, and others that Scuppernong River was named for the grape.

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The writer determined long ago to clear up this confusion. The history has been determined, and the facts, we believe, are of importance to the grape industry of this State and the South, and to horticulture in general.

Collecting the Facts.—It was first necessary to review all of the old books, magazines and periodicals on Southern horticulture and agriculture, especially those on grapes; but very little information could be found regarding the origin of this grape. The most important facts were obtained from files of the old newspapers of the State, especially those published during the early part of the nineteenth century. Information of considerable value was also found in some of the old State and family records.

The writer made an extensive trip to all of the old grape sections in the eastern part of the State. All of the old vines of which any record could be found were examined and carefully measured, and their history was determined as fully as possible. Interviews were held with the descendants of the earliest grape growers; and in this way facts were obtained that throw much light on the subject.

The Original Scuppernong Vine.—It seems to be impossible to locate with absolute certainty the original Scuppernong vine, as no authentic records of the original vine can be found. This, of course, is perfectly natural, as little or no interest was taken in recording the history of any fruits at that early date. The writer feels certain that the original vine was found in northeastern North Carolina, and probably in Tyrrell County.

The earliest authentic record that we have of this grape comes from New Bern, North Carolina. According to a letter by Judge Gaston, dated June 4, 1838, his old neighbor, a Mr. Hickman, brought a young plant of this grape from Tyrrell County, about 1760, and planted it near New Bern, where it became generally known as the Hickman grape.

The most reliable information to be obtained regarding the finding of the original plant of this grape was supplied by the great-granddaughter of the supposed discoverer, Isaac Alexander. The history which has been handed down verbally from generation to generation in that family is, in substance, as follows:

Isaac Alexander went from Mecklenburg to Tyrrell County about the middle of the eighteenth century to take possession of a tract of land granted to him by the English king. In exploring the region, he found not far from Albemarle Sound a wild grapevine bearing large, luscious white grapes. It is said that this was the original vine which many years later was named Scuppernong.

As that region became settled, the vine was rapidly propagated, and, according to several authentic articles, nearly every home in the locality had near it at least one of these vines at the opening of the nineteenth century. It was soon discovered that this grape made ex-

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cellent wine, and as early as 1809 extensive plantings of it could be found in the vicinity of Lake Scuppernong. The grape was commonly spoken of as the White Grape.

On December 21, 1809, the following letter, written by Governor Smith, appeared in *The Star,* a newspaper then published at Raleigh, North Carolina:

"Description of an extraordinary and excellent kind of grape produced in the northeastern part of North Carolina, but not generally known even in that State.

"The grape is large and sweet, of the species of the Fox grape, but white; has been cultivated a number of years in the neighborhood of Lake Phelps, but it is not clearly understood whence it originated. It is supposed to be a native. There are few settlers about the lake but what have a grapevine, which is generally planted at the root of some large mulberry, beech or oak tree, or trained along an arbor of poles lying on forks high enough for a person to walk under and gather grapes conveniently. The vines are never pruned, but suffered to run in a rude state, and many people have vines that will make them a barrel of wine.

"The wine is made by gathering the ripe grapes, picking out all those which are green or bruised, and squeezing the juice into a cider press as soon as they are gathered (for if they lie from one day to another the juice will sour and the wine will always have that taste), when it is put in a clean barrel. To every three quarts of grape juice one quart of brandy is added. After three or four days the wine is raked off till it is clear, and when it gets age is much approved of.

"The process above mentioned is that now followed, but as there are several gentlemen of information sending to the people in that neighborhood to make wine for them, a better process may be discovered. Some have tried fermentation, but it did not answer."

Naming the Scuppernong.—On January 31, 1811, *The Star* published under the heading, "North Carolina Wine from Native Grapes," part of a report made by James Blount, of Scuppernong, North Carolina, who had been appointed to take the census of Washington County. In this report he states that Washington County produced thirteen hundred and sixty-eight gallons of wine from native grapes during 1810. Mr. Blount in his report further says:

"Having taken an account of the wine in my division, I think it my duty to state the result of my inquiries on this small but very interesting branch of our infant manufactures.

"The large white grape from which most of this wine is made is said to be a native of America, and probably of North Carolina, as no person can tell its origin; and I feel inclined to join in this opinion, having about three years ago found a vine with ripe fruit on it of this kind in the woods, where it is very improbable it could have been planted. I am told the grape from the seed will be purple and larger than from the cuttings of the vine, though not so sweet. These vines thrive well on various kinds of soil, but delight most in that which is loose and sandy, and if care is taken to manure them for two or three years it will afterwards only be necessary to keep the weeds clear, prune and scaffold them; and one vine is worth more than fifty apple trees."

The editors of *The Star* add the following comments to Mr. Blount's report:

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"Our readers will recollect a communication on this singular and excellent species of grape (which for the sake of distinction, until we are better instructed, we shall denominate the Scuppernong Grape) in the 239th page of our first volume. That communication excited considerable interest and procured for us another favour of the same kind from Mr. Cooper, which will be seen in page 38 of our second volume."

The grape was named "Scuppernong" because of the numerous plantings of this variety along the Scuppernong River at that time. The name was also given as a compliment to James Blount, who lived near that river and whose excellent articles on this grape attracted much attention at that time.

At that time, Dr. Calvin Jones and Thomas Henderson were editors of *The Star*. The honor, then, of naming this grape belongs to the editors of a Raleigh (North Carolina) newspaper. It is very probable that it should properly be given to Dr. Calvin Jones, who was a noted naturalist, and edited the agricultural part of *The Star*.

The writer feels certain that this is the first time that this grape was designated as *Scuppernong*. He has not been able to find this name used in any of the earlier writings; and Blount, in his report two years previous to that date, speaks of it as "the large White Grape." The following extracts from a letter written by James Saunders of Chowan County, North Carolina, to the editors of *The Star* and published in that paper April 17, 1812, under the title "Scuppernong Grapes and Wine," also lead to the same conclusion:

"Your publishing with such lively interest the properties of that excellent fruit you have named the 'Scuppernong Grape,' while it appeared you were yourselves quite a stranger to it, has induced me to endeavor to prepare and convey to you, this fall, a few slips of that valuable and most luxurious article.

"The usual or common name given those grapes here is the 'White Fox.' So far as my information goes, I think it is most probably a native of Roanoke Island, near Roanoke Inlet, where some have conjectured Sir Walter Raleigh either found or left them. However, I have heard no person object to the name you have given, nor do I expect that any will, for the neighborhood about Scuppernong for several years has abounded with them, and for some time past the inhabitants have been turning them to good account, and, with the help of the encouraging Star, this branch of economy and industry may be brought to high perfection."

Origin of the Word Scuppernong.—The word Scuppernong is a corruption of the Indian word *ascuponung,* meaning place of the ascupo, ascopo, or askopo. The word *ascopo* was the Algonquin Indian name for the Sweet Bay (*Magnolia glauca*). This tree is very abundant along the Scuppernong River.

On the old maps of the State we find that the word *ascuponung* was gradually changed until it has become badly corrupted. Eman Bowen gives it as *cuscoponung* in 1752. On a map by Joshua Fry, published a little later, it is given as *cusponung*. In 1770 John Collet changes it to *Scuponung*. In 1771 James Cook again changes it to *Scuponing*. Some time between 1775 and 1800 it was finally changed to *Scuppernong*.

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Early Names of the Scuppernong.—During the early history of this grape and before the name Scuppernong became generally used, it was known by different names in different localities. The original name was the White Grape. Around New Bern, North Carolina, it was known as the Hickman grape, having been named for a Mr. Hickman who introduced it into that locality. It has also been designated as the Roanoke Grape, White Scuppernong, and Green Scuppernong.

Old Vines on Roanoke Island.

It is often stated that the original Scuppernong vine is still growing on Roanoke Island, where it was first found. The writer feels quite certain that this is a mistake. He examined these vines on Roanoke Island carefully and found that there are five vines of about equal age that undoubtedly were planted there, as they stand in two straight rows. It is true that these vines are very old, but certainly not as old as some in Tyrrell County.

It is not definitely known who carried the young plants of this grape from Tyrrell County to Roanoke Island, but as there was considerable traveling and trading between this island and the mainland along Albemarle Sound, it is readily understood how the vine or vines could have been carried to the island.

It is stated by some that the vines were carried from Tyrrell County to Roanoke Island by Ann Ashbee. This may be possible, as Ann Ashbee in 1799 married Maurice Baum, who in 1797 had purchased the property on Roanoke Island on which the old vines now stand. Certain records seem to indicate, however, that these vines were planted at an earlier date.

SCUPPERNONG A MUSCADINE.

The Scuppernong is a variety of the Muscadine grape, *Vitis rotundifolia*, which grows wild abundantly all through the eastern part of the State. Some writers dispute this, but it is difficult to understand how anyone who has seen the Scuppernong and the wild Muscadine vines can conclude that the Scuppernong is not a native grape. The variety has every characteristic of that species. The trunk, vines, aerial roots, tendrils, leaves, and flowers are characteristic of this species. It is true that the fruit of the Scuppernong is light or whitish in color, while that of the Muscadine is usually dark-purple or black. Still we know that the black Fox grape, *Vitis labrusca*, often produces white-fruited seedlings. Many species normally producing black fruit now and then produce forms which yield white fruit.

Furthermore, the writer has seen a wild Muscadine vine bearing white fruit. (See Fig. 2.) It was found growing wild in the woods on Roanoke Island. He has also seen two white-fruited Muscadines

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now growing on the farm of J. A. Swain, Columbia, North Carolina, which were found in the woods near Columbia, by his father, Timothy Swain. Still further proof is that most of the seedlings of the Scuppernong have purple or black fruit and are as typical Muscadines as can be found anywhere. Then, too, the Pee Dee grape is a white-fruited Muscadine that was originally found growing wild in South Carolina.

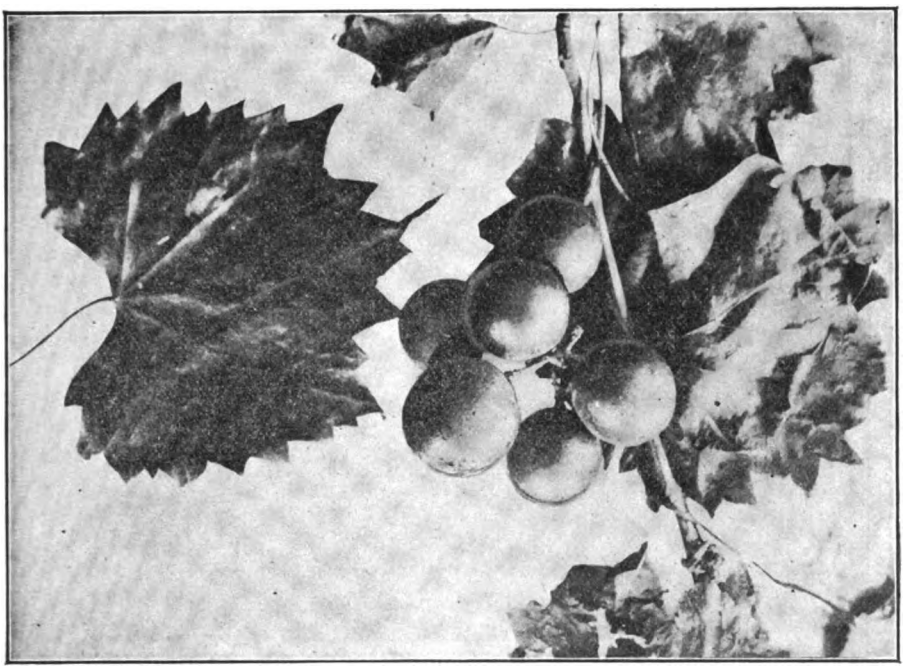

Fig. 2.—Wild White Muscadine.

IMPORTANCE AND CHARACTERISTICS OF THE SCUPPERNONG.

The Scuppernong was the first American or native grape to be brought into cultivation. It has always been the most important variety of this species and has been more generally planted than all of the other muscadines combined. It became popular as soon as introduced because of its great hardiness—growing and bearing well under neglect, and producing an excellent table grape and wine.

The vine is a vigorous grower and attains immense size, as is seen by Fig. 1, which shows a Tyrrell County vine measuring seven feet six inches around the trunk. It is notably healthy, not being seriously affected by either insects or diseases, and is generally a regular and heavy bearer when growing on suitable soils. It is long-lived; some of the vines now bearing good crops are more than a hundred years

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old. One marked peculiarity of the vine is the splitting-up of the main trunk into several divisions, when it becomes very old; also the production of aerial roots when trained on arbors. The vine can be quite readily distinguished from the dark-fruited varieties by the light-colored ends and nodes of the young shoots, the whitish or light-green tendrils and new growths of the aerial roots.

The flowers are perfect, and appear during June in North Carolina. Flowers (and fruit) are borne on the new wood, and not on the old wood, as some of our popular writers have stated. The clusters vary

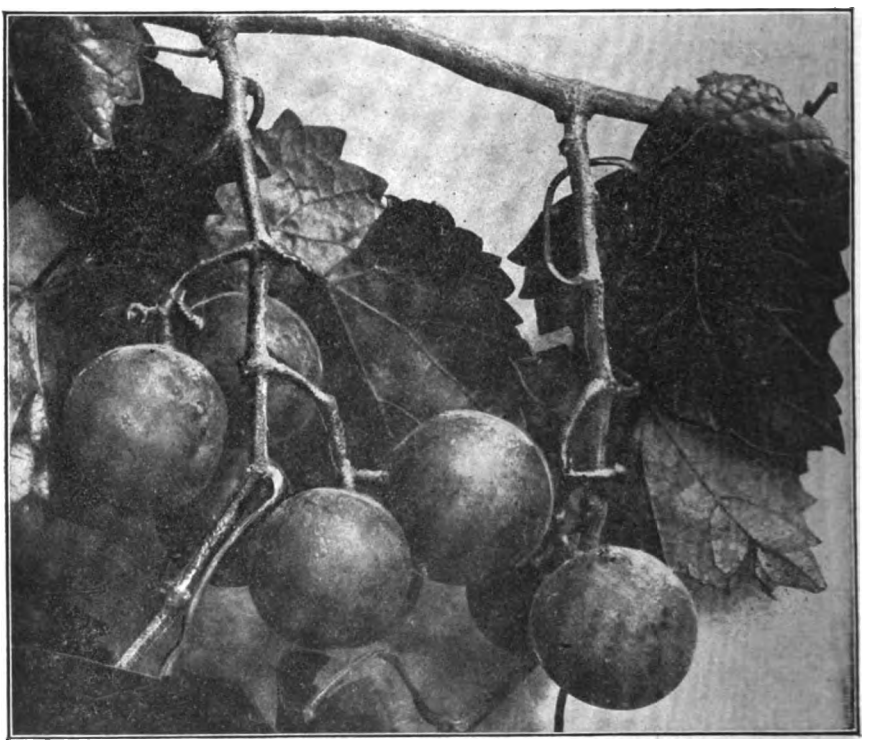

Fig. 3.—Scuppernong.

considerably in size, containing from one to twenty-five berries, usually being much larger on sandy than on clay soils. The berries are round, large, often becoming an inch in diameter; the color varies from pale green to golden russet; skin thick but tender for a Muscadine. The pulp is tender, juicy, with a sweet, rich, characteristic aromatic flavor; and the quality is very good, especially when grown on sandy soils. The chief defects of this grape are the readiness with which the berries shatter from the cluster when fully ripe, and the

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irregularity of ripening of the berries even on the same cluster. The ripening period covers the entire month of September in North Carolina.

The Scuppernong is distinctly a wine grape. It makes a rich, light-colored wine, which has no superior among sweet wines. The large plantings in this State, some of which cover from one hundred to six hundred acres, were made primarily for wine production. A bushel of fruit will produce from three to four gallons of wine.

It is also a good table grape when used soon after gathering; but as the skin is often broken, in picking, where the stem is attached, the fruit sours readily during warm weather. It cannot be shipped successfully except when used for making wine.

This is distinctly a grape for sandy soils, and should never be planted extensively on heavy clay. It is more productive, and the clusters and berries are larger, more juicy and of better quality on sandy or sandy-loam soils than on clay soils.

OTHER IMPORTANT VARIETIES OF VITIS ROTUNDIFOLIA.

Varieties With Dark-colored Fruit.

Flowers.—This excellent late grape comes from Robeson County, North Carolina. It was discovered early in the nineteenth century by William Flowers, about sixteen miles south of Lumberton, in Flowers Swamp. In 1816, Giles Williams visited the parent vine for the purpose of obtaining cuttings. He states that the vine then had the appearance of being about ten or twelve years old. As the fruit of this variety ripens very late and makes an excellent red wine, it soon became the leading black grape in the South for wine making. This is the most popular late variety of this species, the fruit being at its best the latter part of October and during November. The vine is unusually vigorous and is a very heavy bearer. The clusters are large and contain from ten to twenty-five berries, which are large, slightly oblong, purple to black in color, and cling to the cluster unusually well, being equal to any of the bunch grapes in this respect. This is due to the stem being attached on the inside of the fruit, into which the fibro-vascular bundles extend from one-eighth to one-fourth of an inch. This is an important characteristic, as it enables the fruit to be shipped long distances without the shattering of the berries which usually occurs with most of the varieties of this species. The pulp is rather hard and harsh and the flavor is inferior to that of most of the other varieties. For table purposes it has little to recommend it except its late ripening season. For wine making it has no superior; and it will probably make excellent unfermented grape juice. The large clusters and the clinging quality of its berries seem to commend it for breeding work.

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Flowers Improved.—This variety was found by J. M. Shipman, about 1869, near Red Hill Swamp, nine miles north of Whiteville, North Carolina. As it has been only locally advertised, it is not generally grown. The variety has a great deal to recommend it, being superior in some respects to its parent, the Flowers. The vine is more vigorous and more productive; the fruit is similar to the Flowers, but the clusters are larger and the berries more oblong and cling tenaciously to the stem, which is attached internally. It ripens as late as its parent, and for wine making and breeding work seems to be equally promising.

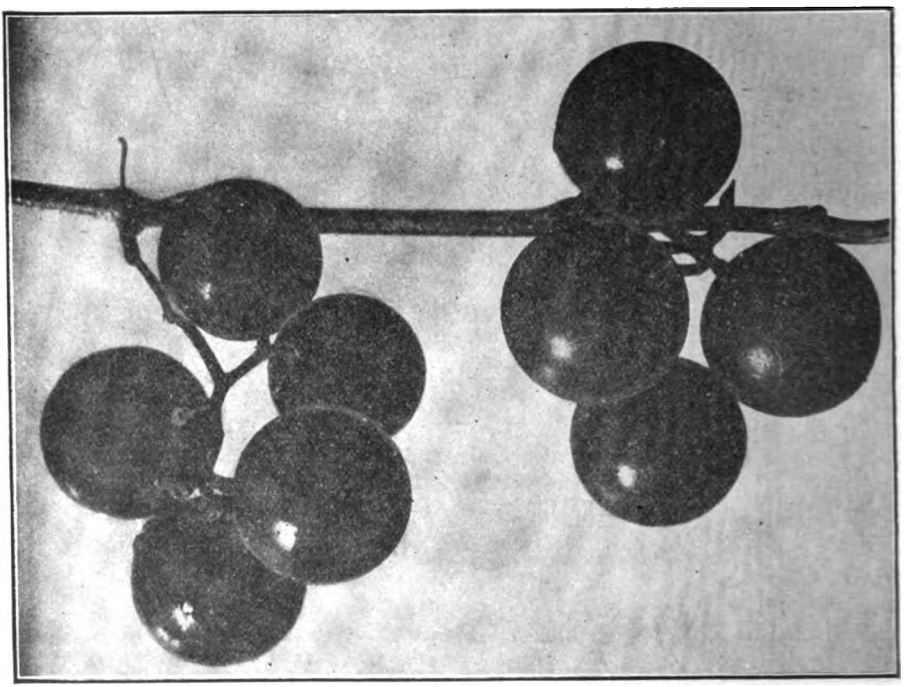

Fig. 4.—James.

James.—This is a native of Pitt County, North Carolina. It was found by B. M. James, in 1866, about three miles south of Parmele, on the Weldon and Kinston Railway. Mr. James was attracted to the grape because of the very large size of the individual berries, and by the fact that they remained on the vines in perfect condition until very late in the season. He propagated the variety and sold it quite extensively. At present it is probably the most widely planted and most popular black grape of this species. The vine is very vigorous and productive; the clusters are of medium size and contain from five to fifteen berries, which are bluish-black

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in color and are the largest of any in this group, often measuring an inch and a quarter in diameter. The skin is thin, the pulp tender and juicy, and the quality very good. The chief defect of this variety is the readiness with which the berries shatter from the cluster as soon as ripe. It is much better suited to clay soils than the Scuppernong and is probably the best general-purpose variety of the group.

Hopkins.—This grape was originated near Wilmington, North Carolina, about 1845, by John Hopkins, an English gardener, who came to that place in 1840. It is said to be a cross between a wild

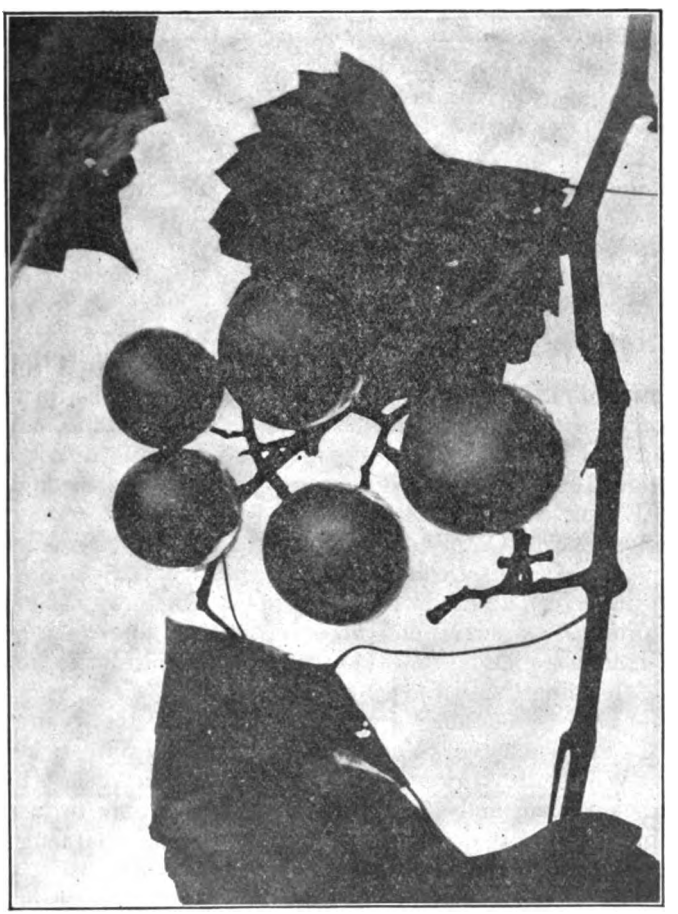

Fig. 5.—Memory.
(Clusters usually larger than that illustrated.)

black grape and the Scuppernong. It is not known at present what the wild black grape was, but it is very probable that it was a muscadine. Others maintain that this variety is simply a superior seedling of the Scuppernong. As the fruit of this grape ripens earlier than

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that of any others belonging to this species, and as it is of excellent quality, it is rather strange that this grape has not been more widely grown. The vine is exceedingly vigorous and healthy, the clusters and black berries are large, the pulp is tender, and the flavor unsurpassed. This variety is a valuable member of this group, as it lengthens the ripening season nearly a month, beginning early in August. It should be found in every home vineyard.

Memory.—The Memory was introduced, in 1868, by the late T. S. Memory, of Whiteville, North Carolina. Some of its characteristics and the fact that it was found in his vineyard among some Thomas grapevines indicate that it is a seedling of the Thomas. The grape proved to be an excellent one, and Mr. Memory named it for himself. The vine is probably the most vigorous grower of this group. The fruit ripens in September; the clusters are of good size, and the berries cling to the clusters until they become shriveled. The berries are very large, oval to oblong in shape, and jet-black in color. The pulp is juicy, very tender, exceedingly sweet and delicious. This variety has not become as widely distributed as its good qualities merit. It should be in every home vineyard, and for local market it has no superior in this species.

Mish.—This variety was found by William Henry Mish, about 1846, at Swann Point, on the Pamlico River, about six miles east of Washington, North Carolina. He found it growing in the sand twelve or fifteen feet from the river. The variety was named for the finder and introduced by him shortly after being discovered. It soon attracted much attention and was widely planted throughout the South. Extensive plantings of it can be found at present around Washington, North Carolina. The vines are vigorous and very productive. The clusters are large; the berries medium in size, round, purplish in color, and adhere well to the clusters. The pulp is tender, juicy, very sweet and of exceptionally fine quality. This variety should be planted in every vineyard, because of its fine flavor and good shipping qualities.

Sugar.—This is another variety introduced by the veteran grape grower, T. S. Memory, of Whiteville, North Carolina. It was found by him at Whiteville, between 1865 and 1870. The variety has never been widely grown, and at present the writer is able to locate only a few vines of it. It does not possess any special characteristics to commend it.

Tenderpulp.—Tenderpulp originated in the vineyard of D. P. High, at Whiteville, North Carolina, about 1868. It is very likely a seedling of the Flowers. Although the pulp is very tender, it is low in sugar content, and of poor quality. It has nothing to commend it except its exceedingly tender flesh, and its productiveness. Because of its poor quality, it has never become very popular.

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Varieties With Light-colored Fruit.

Pee Dee.—The Pee Dee was discovered by some negroes on Dr. H. Williamson's place at Darlington Court House, South Carolina, just prior to the Civil War. During the war, it was brought to Dr. Williamson's attention. It was undoubtedly an accidental seedling, as it was found growing over a fence where everything seemed

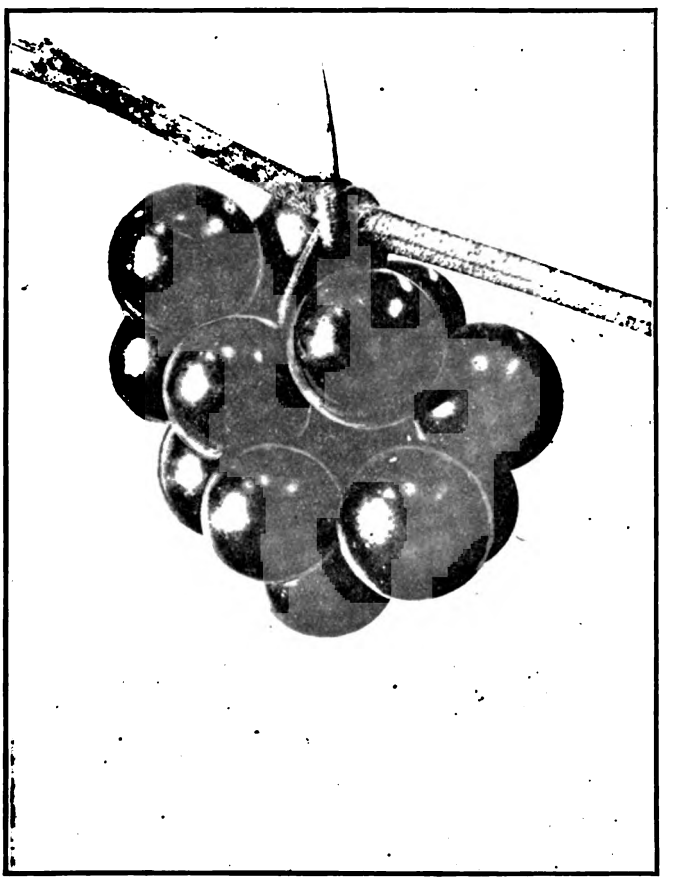

Fig. 6.—Mish.

to indicate that it had not been planted. This variety never became very popular or widely distributed and at present is seldom met with. It is an interesting variety because the color of the berries is similar to that of the Scuppernong. It has nothing to commend it over that variety except its late ripening habit. For wine and jelly it is excellent.

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Varieties With Reddish or Reddish-purple Fruit.

Thomas.—This excellent variety was found about 1845, in the woods four miles from Marion, South Carolina, by Drewry Thomas, and takes its name from Mr. Thomas, who introduced it. The variety at once became popular because of its delicious sweetness, and has been widely planted. It is unique as a muscadine because it is the only variety of the species that has reddish or reddish-purple fruit. The vine is not a vigorous grower, but is very productive.

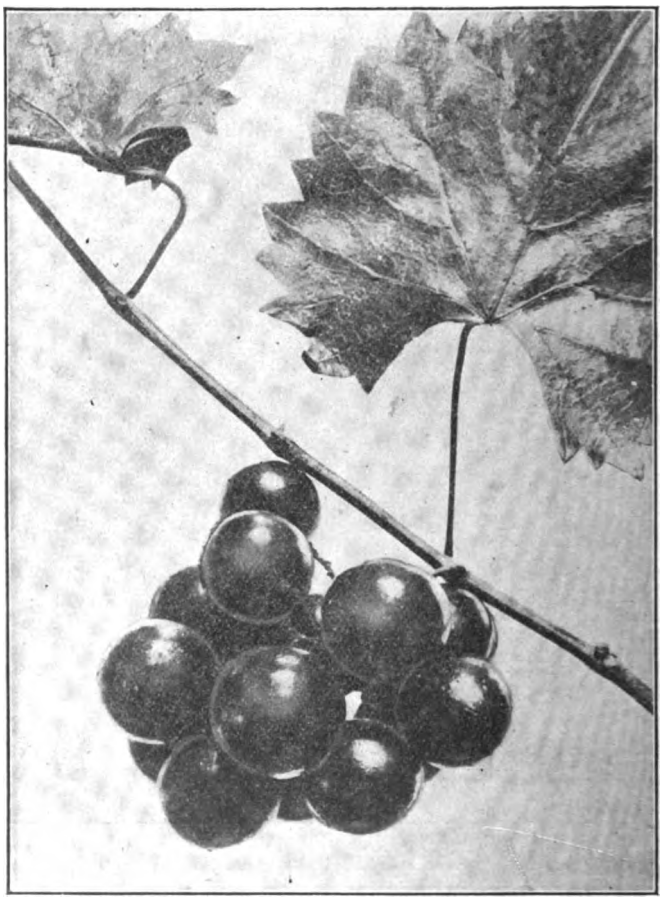

Fig. 7.—Thomas.

The clusters are large, and the berries shatter readily when fully ripe. The fruit ripens early, and the berries are small, round, reddish, with a thin, tender skin. The pulp is tender, juicy, sweet, and exceptionally rich. As a table grape the quality could hardly be im-

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proved on. The only other variety that equals it in this respect is the Memory. It should be planted in every vineyard, and if but one variety is to be planted for home use, Thomas is the variety.

Unimportant Varieties.

There are several varieties of this species grown only locally, and it is quite probable that they will never be widely grown, or become of any special importance. Such varieties are Beula, Westbrook, Jeter, and Seedlin.

MEN WHO POPULARIZED THE MUSCADINE GRAPES.

Since North Carolina is responsible for the introduction of most of the varieties of this species, it is only just to mention the names of the men who were largely responsible for their introduction. These men were Thomas Blount, of Washington County; Hickman, of Craven County; Calvin Jones, of Wake County; Sidney Weller, of Halifax County; Henry Mish, of Beaufort County; T. S. Memory and D. P. High, of Columbus County; L. Froelich, of Duplin County; and J. Van Buren, of Georgia.

RECOMMENDATION OF VARIETIES.

a. For home use:
Hopkins, Thomas, Scuppernong, Mish, Memory and Flowers Improved.

b. For wine:
Scuppernong, James, Flowers and Flowers Improved.

c. For unfermented grape juice:
James, Mish, Memory and Flowers.

d. For general market:
Mish, Memory and Flowers Improved.

IMPORTANCE OF MUSCADINE GRAPES IN THE SOUTH.

The varieties of this species have always been the most important grapes in the warmer sections of the South. They are especially well adapted to the climatic and soil conditions of the Coastal Plain region from southeastern Virginia to Texas. The vines grow luxuriantly, and as the bloom appears very late, they are regular bearers. The fruit is practically free from fungous diseases and is very rarely attacked by insects. Most of the muscadines ripen their fruit comparatively late in the season, after most other grapes are gone, and at the best season for wine making. Most other grapes grown in the South are quite subject to rot and insect injury, and the vines are short-lived.

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MUSCADINES IN NORTH CAROLINA.

The Muscadine grapes are not equally well adapted to all parts of the State. They reach their greatest perfection in the Coastal Plain section. This, of course, is quite natural, as it is the home of most of these varieties. The climatic and soil conditions there are admirably suited to them.

They also do well in the Sand Hill region of the State. Even on the poor, white, dry sandy soils where few other plants thrive, these grapes reach a high degree of development.

They will grow quite well in the Lower Piedmont section, and especially on sandy soil, but the clusters are much smaller and the flavor inferior to those grown in the Coastal section. This is especially true on clay soils. For commercial purposes they should not be planted in this section.

Attempts to grow them in the Mountain and Upper Piedmont sections have usually resulted in failure. While the vines grow well in the Upper Piedmont, they very seldom bear fruit. They should not to be planted extensively at an elevation greater than six hundred to seven hundred feet.

MUSCADINES FOR MARKET.

These grapes are especially well suited to the family vineyard and for wine making, and may be marketed with some degree of success. Considerable objection has been raised against them for market purposes because of the small size of the clusters, but this objection does not always hold, as some of the varieties bear as many as fifteen to twenty-five berries to the cluster. Other things being equal, the clusters are much larger when grown on sandy soils than on clay soils. With some of the varieties the fruit shatters readily from the cluster as soon as ripe; with others the berries cling as tenaciously to the cluster as with any other variety of grapes.

UNFERMENTED GRAPE JUICE.

The question is often asked whether these grapes can be used successfully for making unfermented grape juice. Careful experiments by one of the largest wine manufacturers in the South show that some varieties of this species, especially the dark-fruited varieties, are well suited for this purpose. The writer knows of no reason why this should not become an important industry in the South. Although the Scuppernong does not seem to be so well suited for this purpose as the dark-fruited varieties, yet carefully conducted tests have shown that it may be successfully used.

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SELF-STERILITY IN MUSCADINE GRAPES.

One of the most important questions connected with the growing of Muscadine grapes is whether or not they are self-sterile. At present this cannot be definitely answered, at least for all varieties; and more and better work will have to be done to determine this point. Certainly the same answer may not apply to the group as a whole. It is possible that some varieties will prove to be self-fertile and others self-sterile. Undoubtedly soil and climatic conditions have some influence on fertility in this group. Some of the varieties, notably the Scuppernong, appear to be more nearly self-sterile on the clay soils in the Piedmont section than on the sandy soils in the Coastal section. Some Scuppernong vines appear to be self-fertile and others self-sterile under apparently similar conditions.

The writer's work, while confined to only one season and one section of the State, gave decided results. A large number of flower clusters of the Scuppernong and Flowers were covered with paper bags before the flowers opened, and not a single fruit was produced. On the same Scuppernong vines other flower clusters were covered similarly, but later when the stigmas became receptive a flower cluster from a *male* vine was tied to each of these Scuppernong flower clusters. Three-fifths of these matured normal-size clusters of fruit.

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BULLETIN 202 MAY, 1909

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

MANUFACTURE AND MARKETING OF COTTAGE CHEESE, SKIMMILK-BUTTERMILK AND ICE-CREAM.

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N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,

UNDER THE CONTROL OF THE

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The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

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CORN WEEVILS AND OTHER GRAIN INSECTS.

By R. I. Smith, Entomologist.

Like practically all agricultural products, corn and other grains are subject to the attack of numerous destructive insects, some of them commencing their depredations in the ripening grain in the fields, while others abide solely in the barns, storerooms or cribs where the grain is stored. Farmers of North Carolina and, in fact, of all the Southern States, expect a greater or less number of weevils or other insects to be in their granaries each spring, and consider it fortunate when only a few are present. As a general rule, the injury inflicted to the grain is underestimated, and the loss in total weight and feeding value is accepted as an annoying but unavoidable condition.

The actual loss occasioned by insects in whole grain and the various stock foods cannot be accurately estimated; the grain is not only reduced in weight and consequent selling value, but is often rendered wholly unfit for human food and less valuable as food for live stock.

As an example of the extent of the injury caused by grain insects, a consideration of the value of the grain crop will be of interest. The corn crop for North Carolina in 1908 was valued at $39,631,000 and the wheat crop at $6,078,000, a combined total of $45,709,000. Since there are no statistics to show the actual annual injury caused by insects, it may be conservatively estimated at five per cent, which is lower than the actual per cent of damage reported for certain other Southern States in previous years. Five per cent of the total is $2,285,450, an amount representing the possible annual damage by grain insects to corn and wheat crops alone in North Carolina.

The list of really injurious species of insects attacking stored grain, and the principal feed stuffs manufactured therefrom, number twenty and upwards. There are two true weevils and at least one dozen other forms known as beetles in their adult stage, while we find six common and injurious species whose parents are moths. Ten of the most important and conspicuous of this number are described in the pages following. The principal damage to whole grains is caused by the rice or black weevil and the angoumois grain moth or fly weevil, but the others mentioned are frequently present in destructive numbers. In eastern North Carolina the black weevil probably predominates, but in the western section the fly weevil holds first position. In many localities these two species and others of less importance are found working together, sometimes actually occurring in the same kernels of corn.

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For the reader who is not familiar with the grain insects, the illustrations (original photographs by the author) and statements concerning the life-history of each will help to show the importance of this subject. It is not always realized how rapidly these insects—the true weevil, for example—may increase in numbers under favorable conditions, nor is it known by all that grain may become infested in the field before harvest. With species that produce only one generation annually, it is not realized how important is the matter of killing them in the larval and pupal stages, an example being the dark meal worm. These and other points given under the discussion of each species in the following pages are necessary for an intelligent understanding of the grain insect problem.

The presence of insects in grains, meals and food stuffs is not easily prevented, nor is it an easy matter to kill them after once gaining a foothold, but certain preventive and remedial measures may be adopted to avoid a portion, at least, of the annual loss. A portion of this bulletin is devoted to the discussion of the best known and most effective control measures. Attention is called especially to the carbon bisulphide fumigation treatment, as this has for many years been principally recommended for destroying grain insects. The writer's recent experiments show conclusively that fumigation with this substance cannot give satisfactory returns when employed under ordinary farm conditions where grain is stored in cribs or rooms that cannot be made sufficiently tight to hold the poisonous fumes long enough to kill weevils.

The purpose of this Bulletin is partly to give farmers a more accurate knowledge of the various grain pests, and to caution them to use preventive measures wherever possible, and partly to explain the limitations in the use of carbon bisulphide for fumigation of infested grain.

THE GRAIN WEEVILS.

The popular name for all insects working in stored grain is weevil; but restricting ourselves to the correct meaning of the term, there are only two true grain weevils. These are the rice weevil and granary weevil, two closely related species, which in the mature stage are small dark-colored beetles possessing a snout or proboscis about one-third as long as the body, and belong among a group of snout beetles that include such familiar forms as strawberry weevils, corn bill-bugs, plum curculio, acorn weevils, and many others. The grain pest known to farmers as the fly weevil, a species fully as destructive as the true weevils, should be placed in a different class, because of the mature form being a small moth which does no damage other than to lay eggs; and the same may be said of all the grain pests that develop

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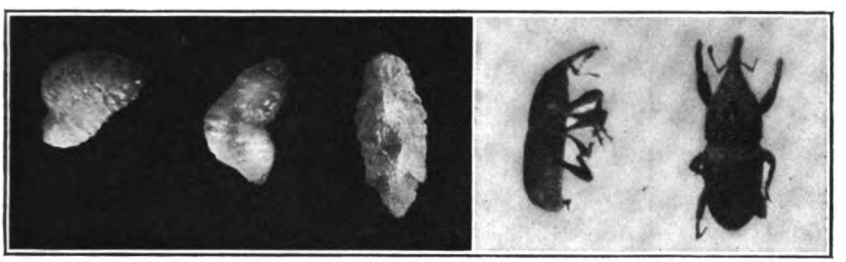
into moths. The remaining grain insects, which are different forms of beetles in the mature stage, do not belong to the group of snout beetles, and are not properly called weevils.

The Rice Weevil (Black Weevil) (*Calandra oryzæ*, Linn).

The name corn weevil or black weevil is usually applied to this species, although its original name is rice weevil, so called because of its being first discovered in that grain. The former names are also applied to a near relative, the granary weevil; hence we should preserve the title rice weevil to make this species distinctive. India is thought to be its native home, but the species may now be found in nearly every grain-producing country of the world, and is particularly abundant in the Southern States, but is less numerous farther North.



a *a* *b* *c* *d*

FIG. 1.—The Rice Weevil or Black Weevil; *a*, full-grown larvæ; *b*, pupa from beneath; *c* and *d*, adults—about five times natural size.

Injury is caused by the adult beetles eating into grain for food and shelter, as well as by the larvæ that feed inside the kernels. Small grains like wheat and rice furnish food for only a single larva in each kernel, but in corn three or four may mature. It has been estimated that one pair will, in the course of a year, produce over 6,000 descendants. The effect on the grain is to reduce the weight materially, and consequently its selling value, and renders the grain unfit for human consumption.

DESCRIPTION AND LIFE-HISTORY.

The mature weevils (Fig. 1, *c* and *d*) average to measure about one-sixth inch, including the snout, which is about one-third the length of the body. The general appearance is dark reddish-brown, but individuals vary from a light brown to nearly black; the thorax presents a network of minute round punctures; the wing covers or first pair of wings bear a more or less distinct red spot near the base and tip of each wing, while the whole surface bears small punctures arranged in longitudinal rows. Underneath these, the second pair of wings are

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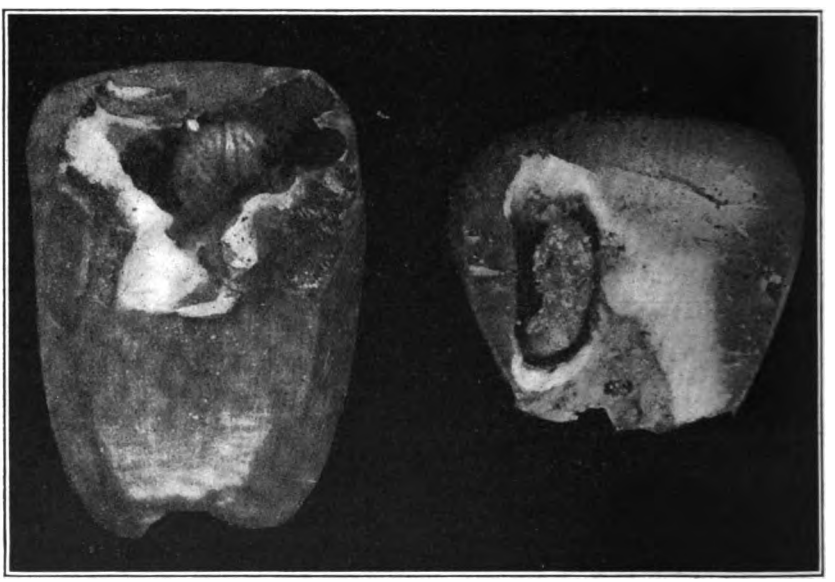
membraneous and well developed, enabling the beetles to fly to fields remote from the granaries. The snout bears a pair of elbowed antennæ (feelers) and terminates in strong biting jaws.

The larva (Fig. 1, *a*) is white, fleshy and robust, possessing strong, horny, brown jaws. Legs being unnecessary, are not present. When fully grown the larva transforms to a pupa (Fig. 1, *b*) in its burrow, in which stage it shows the general size and outline of the future beetle, but is transparent and white in color.

The eggs are small and white and are laid in minute punctures made in the grain by the jaws of the female weevil. The tiny larva when just hatched commences at once to gnaw toward the center or makes a channel for some distance just under the skin of the grain.



a *b*

FIG. 2.—The Rice Weevil larva and pupa *in situ* in corn; *a*, larva; *b*, pupa; both enlarged five times.

The channel is always filled with a fine powder, quite different in appearance from the pellet-like excrement left by the larvæ of the angoumois grain moth. When nearly grown the larva provides for the easy escape of the mature weevil by leaving only a thin skin over the burrow, and then quietly transforms to a pupa, which in time changes to the mature weevil.

Four or five generations mature each year. At Raleigh the writer observed adult weevils laying eggs on ripening corn in the field, on September 12, 1908; he also found a few small larvæ. From an ear

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of corn collected on this date adult weevils emerged on October 17, showing that in this instance the eggs must have been laid early in September, or possibly in August, because it is known that the period from egg to adult is about six weeks in warm weather. In addition to the weevils that fly to the fields and attack the ripening grain, many continue to breed all summer in the granaries where food is obtainable, and whenever infested grain is kept until the new crop is housed, the weevils are furnished ideal conditions for rapid development. It is impossible to prevent grain from becoming infested in the field, but the farmer can see that no weevils are present in the barns or granaries when the crop is housed. The practice of keeping corn the year round and sometimes putting new corn on top of the remains of the previous year's crop cannot be too strongly condemned.

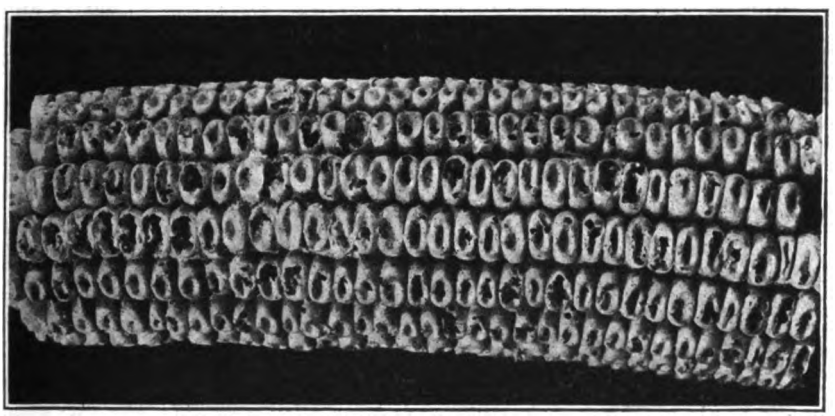

FIG. 3.—Work of Rice Weevils and the Cadelle in two-year-old corn.

Wheat, oats, rice and other grains serve as food for the rice weevil, and may be infested in the field at about the time the kernels are ripening. With corn it has frequently been observed that the ears having a tight husk are seldom attacked by weevils, but we are confronted with the fact that the corn ear-worm (*Alabama argillacea*) frequently makes entrance and exit holes through the husk of the most perfect ears, and by means of these openings the adult weevils enter ears that would otherwise be inaccessible to them.

The general discussion of preventive and remedial measures is given on pages 22 to 27.

THE GRANARY WEEVIL. (*Calandra granaria,* Linn).

In general size, appearance and feeding habits the granary weevil is almost identical with the rice weevil. It may be distinguished, however, by its lack of membraneous wings, consequently being unable

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to fly, and by the thorax being sparsely and longitudinally punctured. It is also generally somewhat lighter in color than the preceding species. It requires only passing mention here, for the rice weevil far surpasses it in numbers and destructiveness in the Southern States. Owing to its lack of wings, the granary weevil remains in the barn and corn cribs; hence, where proper precautions are taken to feed or remove all infested corn each fall before the new crop is housed, this species can never become abundant like the preceding one. The granary weevil infests wheat, corn, barley and other grains, but is generally considered as a corn weevil.

GRAIN BEETLES AND MEAL WORMS.

There are nearly a dozen species of beetles that attack grain, meal, bran, middlings, and many food products, and often work side by side with the true weevils. The cadelle, which is described, is nearly always found in the barns and grain rooms of the Southern States, and several smaller species of grain beetles are equally abundant, but do less damage because of their small size. The species that the writer has found most abundant are the following:

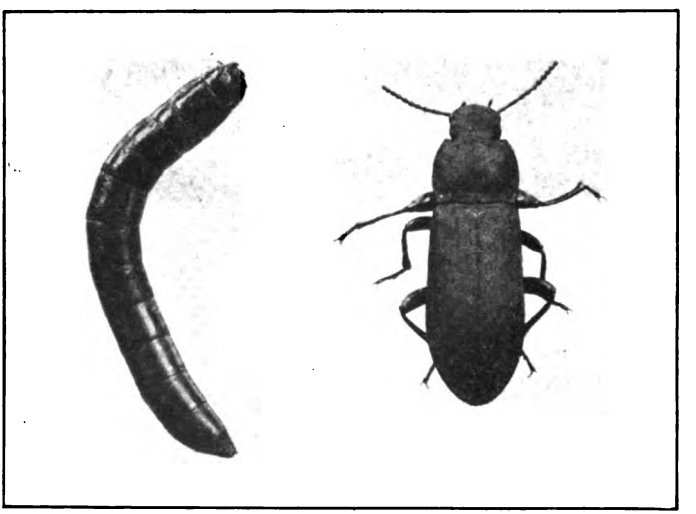

FIG. 4.—Dark Meal Worm and parent beetle. Two and one-half times natural size.

THE DARK MEAL WORM (*Tenebrio obscurus*, Linn).

This species, illustrated in Fig. 4, feeds mainly in meal, bran and other stock feeds, but may be found at times in whole grains. They often become abundant in grain bins that are not often entirely

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emptied, a good illustration having come under the writer's observation recently, in a barn at West Raleigh where hundreds of the beetles were found during the first and second weeks of May.

There is only one generation each year. The beetles normally appear about the last of April, in this section, and soon deposit small, white, bean-shaped eggs in whatever food is at hand. The eggs hatch in two weeks into small delicate larvæ, which increase rapidly in size, and are said to become fully grown in about three months.

The worms, when grown, are darkish brown in color, with a smooth waxy skin, resembling a wireworm. They attain a length of about an inch and live in this stage without much change during the winter, transforming in spring to whitish pupæ and eventually to mature beetles. These are dull black in color and average a little less than three-quarters of an inch in length. The beetles are nocturnal in habits, scampering rapidly out of sight when suddenly exposed by the opening of a grain box.

The meal worms frequently breed in the bottom of grain bins or in corners where meal, flour or other refuse material has accumulated, but as they develop only one generation a year, thorough cleaning-out of all infested material during July or August, after the eggs are laid, will suffice to control them.

The Yellow Meal Worm (*Tenebrio molitor,* Linn).

Differing from the preceding species in color, but not much in size or habits, the yellow meal worm is frequently found in stock foods, flour mills, bakeries, feed rooms and similar places. The worms are yellow, shading to darker toward each end and near the articulation of each joint, but in other respects do not differ from the dark meal worm. The adult beetles of this species are blackish and shining, instead of dull black, and have certain other points of difference, but their habits are the same as the parents of the dark meal worm.

The Cadelle (*Tenebriodes mauritanicus,* Linn).

A widely distributed species occurring in all manner of prepared food products, as well as in grain, meal and other stock foods, is illustrated in Fig. 5. The larvæ was given the name "cadelle" in France many years ago, when it was classed as a meal worm, and in recent years some authorities have claimed that this species is predaceous and carnivorous rather than granivorous, but the writer has observed that it possesses both habits. Chittenden states that he has proved it to be both a feeder on grain and other insects. Consequently the cadelle represents an insect that is both beneficial and injurious. In old corn it is particularly destructive, and in my opinion the injury

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caused is greater than its beneficial work by destroying other grain insects. It is not uncommon to find cadelle larvæ feeding in grain from which weevils have emerged.

The parent beetle (Fig. 5) is elongate, flattened, and nearly black, measuring about one-third of an inch in length. The larva (Fig. 5) measures nearly three-fourths of an inch when fully grown, its general coloring being whitish, with the head and anal segments dark brown, and the three thoracic segments marked with brown. The body is fleshy and tapers gradually toward the head.

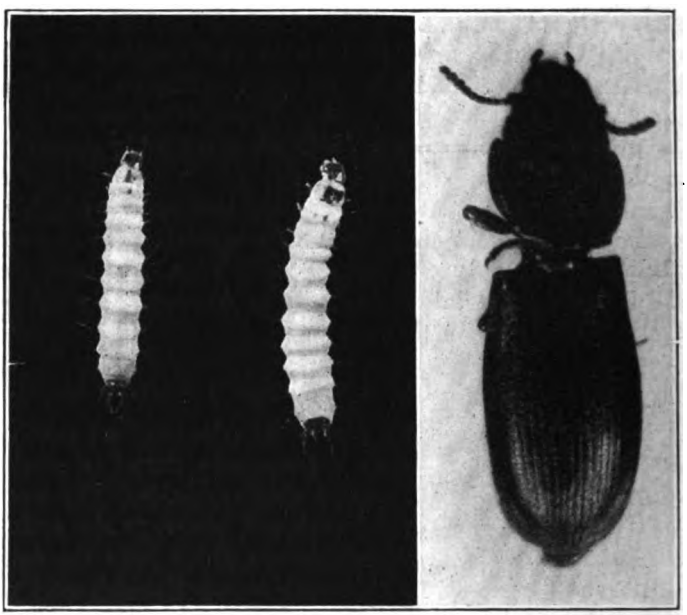

FIG. 5.—The Cadelle; full-grown larvæ twice natural size; parent beetle seven times natural size.

Both the larva and adult feed in the grain, frequently changing their positions, perhaps in search of weevil larvæ, but most assuredly they cause much injury and should be dealt with like any other grain insect.

Only one generation is produced annually, which is very fortunate, as otherwise the species might prove one of our worst grain insects. Recent experiments by the writer have shown that the beetles are more difficult to kill by fumigation with carbon bisulphide than the adult corn weevil, although the larvæ are quite readily destroyed by this treatment.

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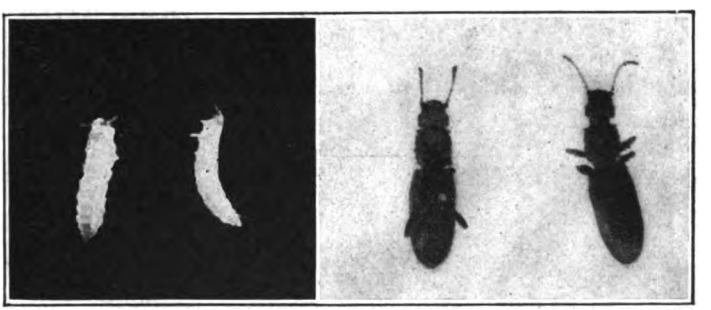
THE SAW-TOOTH GRAIN BEETLE (*Silvanus surinamensis,* Linn).

This is one of the smallest, but most common, of the insects attacking grain and nearly all food stuffs. Its small size enables it to penetrate the smallest cracks, and its taste for all kinds of food causes it to be found in granaries, storerooms, groceries, pantries and bakeries, even feeding on red pepper. As a grain pest this species does not actually devour enough to render its presence a source of great loss, but it is nevertheless a great nuisance, and infested food stuffs may be rendered unfit for consumption. Both the larvæ and adults have the habit of eating holes in paper bags in search of food.

The mature beetle (Fig. 6, *b*) is only about one-tenth inch in length, much flattened and chocolate-brown in color. The thorax bears six minute points or teeth on each side, which may be seen in the illustration.

The larva (Fig. 6, *a*) is a slender white worm with darker markings, and is very active, moving frequently from one place to another.



a *b*

FIG. 6.—The Saw-tooth Grain Beetle; *a*, nearly grown larvæ; *b*, parent beetles—both greatly enlarged.

There are said to be six or seven generations annually, the entire life cycle being covered in twenty-four days in midsummer.

The writer's experiments have shown that these beetles are killed by carbon bisulphide fumes a little more easily than are the corn weevils or other grain beetles mentioned above.

GRAIN AND MEAL MOTHS.

We now come to grain insects of which the parents are moths, and among them are found some very destructive species. Only one, the larvæ of the angoumois grain moth, develops entirely in the kernels of grain, either wheat, corn, barley or other cereals, while the remainder have the habit of passing from one grain to another, marking their progress by a silken tube or web, or working their way through meal,

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bran or whatever material they occur in, transforming the same into a worthless webby mass. Owing to this habit the meal worms cause damage all out of proportion to the amount of food they actually consume.

In point of importance the angoumois grain moth should stand next to the rice weevil—in some localities, in fact, greatly outstripping it in numbers.

The Angoumois Grain Moth (Fly Weevil) (*Sitotroga cerealella,* Ol.).

The Southern farmer generally applies the term "fly weevil" to this species to distinguish it from the rice or black weevil, but the term is hardly appropriate, because the adult flying moth is simply the parent form of the worm that feeds in the grain. This species does not

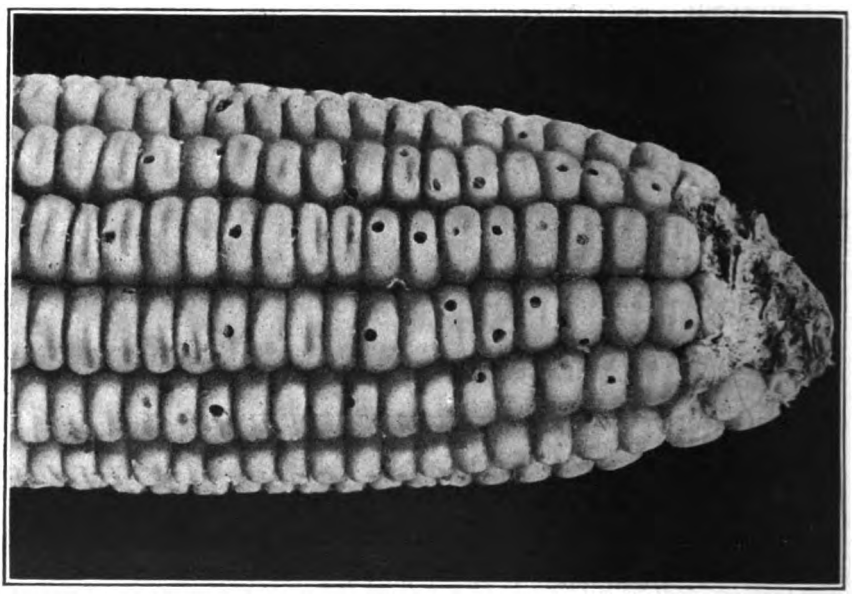

Fig. 7.—Showing the work of the Angoumois Grain Moth, as often seen in October—slightly enlarged.

attack meal or food products, but lives in the whole grain, a single kernel of corn often furnishing food for two or three larvæ. The characteristic appearance of an infested ear of corn, as sometimes found in the field during October or November, is shown in Fig. 7. Fig. 8 shows an ear from which several generations of moths have emerged, such specimens being frequently found in two-year-old corn.

The moths are seen in Fig. 9, the male always being of smaller size. In color they are light grayish-brown, with lines of black, and

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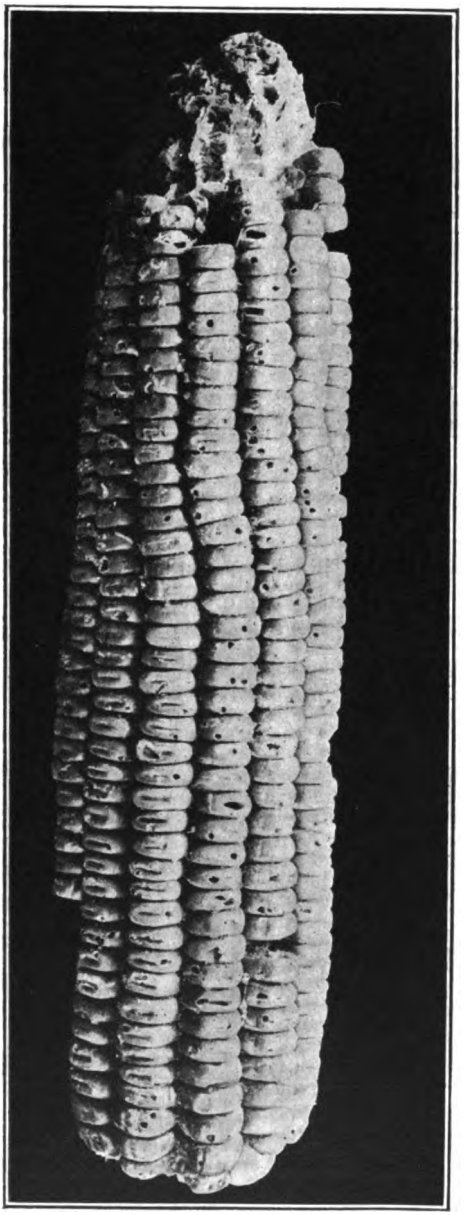

FIG. 8.—Ear of corn from which several generations of the Angoumois Grain Moth have emerged—slightly reduced.

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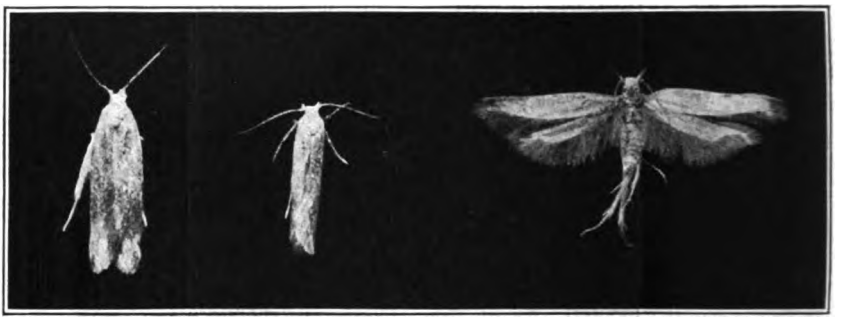
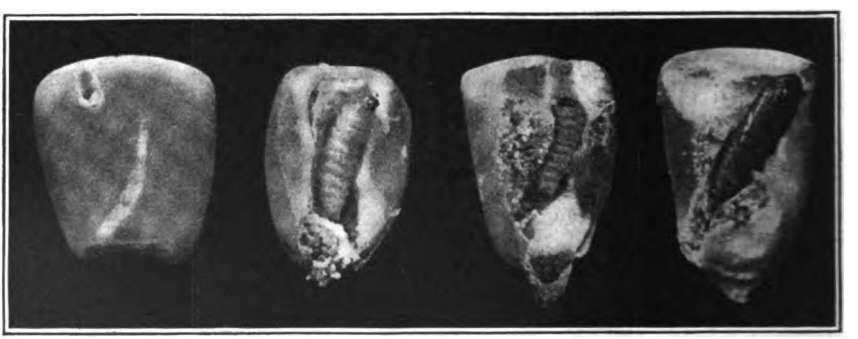
measure across the expanded fore wings a little over one-half inch. The front wings bear a fringe of long hairs on the anal edge, and the hind wings bear a continuous border of the same. The moths are very delicate, easily crushed and readily killed by poisonous fumes.



a *b* *c*

FIG. 9.—The Angoumois Grain Moth; *a*, female; *b*, male; *c*, male with wings expanded—all two and one-half times natural size.

The larva (Fig. 10, *b*) is white, distinctly segmented and attains a length of about one-quarter of an inch. The jaws are brown and horny. When grown the larva transforms to a light-brown pupa (Fig. 10, *c*) in its feeding place, but provides beforehand for the escape of the adult by leaving over its burrow only a thin skin of the grain, through which the moth easily manages to escape.



a *b* *b* *c*

FIG. 10.—The Angoumois Grain Moth; *a*, natural appearance of infested kernel; *b*, larvæ in natural position; *c*, pupa, same—all two and one-half times natural size.

The eggs, deposited singly or in clusters, are at first white, but soon turn reddish and hatch in four to ten days, depending on the temperature. Each female lays from sixty to ninety eggs. The larva when hatched is active and soon penetrates the grain, leaving an almost

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invisible opening. In about three weeks the larva is fully grown and transforms to the pupa stage. Both larva and pupa are shown *in situ* in Fig. 10 in partially opening kernels of corn.

During the year five or six generations of moths may be produced. Farmers commonly remark that grain becomes infested in spring when large numbers of moths are seen flying in the granaries—thus gaining for them the name "fly weevil"; but in reality the grain is generally first infested in the field. At West Raleigh the writer found, in 1908, that many moths had matured and escaped from ripening corn in the field on September 10. Two days later an ear of corn was taken and placed in a glass jar, and by September 27 thirty-four moths had emerged. From this it is seen that the first brood in the field must mature here as early as the beginning of September, and it may be that the writer missed the first brood. In any event there must be two full broods and probably three during the summer and fall, the winter being passed in the larval stage. In spring the moths commence to emerge in April, and earlier in the warmer sections of the South, and succeeding generations may mature about every six weeks.

Grain in the field is evidently not infested until nearly grown, or in such condition that the first moths mature about when the grain is ripening. It is certainly a bad practice to leave corn cut and stacked in the field during the fall months, for in such condition more ears are exposed to egg deposition than would be if the corn were stored in the grain cribs. The moths will not be present in the granaries during the fall months if proper precautions have been taken to get rid of all infested grain of the previous year's growth.

The Indian Meal Moth (*Plodia interpunctella,* Hbn.).

This species is not a serious grain pest, but the writer has reared a considerable number of the moths from corn infested principally with the angoumois grain moth. The usual food of the Indian meal moth larva is said to be dried fruit, seeds, nuts, roots and condiments as well as meal and grain products.

The parent moth is shown in Fig. 11. The fore wings expand a little over one-half inch, and may be described as having the inner third dirty whitish-gray, and the outer two-thirds reddish-brown. The hind wings are of a uniform light-gray color bordered with a fringe of hairs. When seen in houses they are frequently mistaken for clothes moths.

The larva or caterpillar reaches a size of about three-eighths of an inch, and unlike the species just mentioned, does not live in a single kernel of grain. On the other hand, they pass from one place to another, spinning large quantities of silk and fastening the particles of food together. It is claimed that they have a special fondness for the

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embryo of wheat, one caterpillar often ruining dozens of kernels for seed or food purposes. The entire life cycle may be passed, from egg to adult, in five weeks in warm weather; hence several generations a year may be expected.

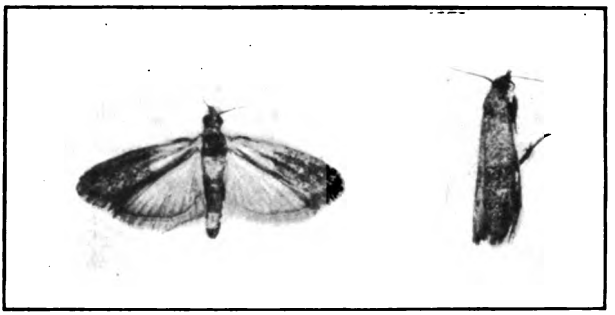

FIG. 11.—The Indian Meal Moth, enlarged two and one-half times.

The parent moths are easily killed by poisonous fumes and the larvæ are more easily killed than those of the angoumois grain moth or corn weevil, which live entirely within the grain.

THE MEDITERRANEAN FLOUR MOTH (*Ephestia kuehniella*, Zell).

As a pest in stored grain this species is of slight importance, but it has no equal in destructiveness in flour mills, and in the absence of its favorite food, such as flour or meal, it will attack grain and flourishes on bran and cereal foods. The writer has bred this species from cotton-seed meal. The history of this insect commenced in 1877, when it was discovered in a flour mill in Germany and later invaded Belgium and Holland. In 1892 it was reported as occurring in mills in Canada and during 1895 in New York and Pennsylvania.

The moth is described as having a wing expanse of a little less than an inch, the fore wings being blackish-gray with transverse black markings, the hind wings being dirty whitish color.

The larval stage is really a caterpillar that reaches a length of one-half inch and is pink in color. Its full growth is attained in about forty days, after which it changes to a reddish-brown pupa in a silken cocoon.

The caterpillars have the habit of spinning silken tubes wherever they travel, feeding from the mouth of the tube, and it is this habit that renders them so injurious. Infested flour or meal becomes matted together and lumpy, clogging the machinery in mills and rendering the material in which they feed unfit for human consumption. When such infested material is discovered it should be destroyed immediately, and wherever mills are found infested, prompt measures

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should be taken to exclude the pest by destruction of the insects in infested material, by thorough cleaning and by fumigation. Afterward, a strict inspection and quarantine should be established to prevent the entrance of infested material. Farmers need not fear this pest, but millers should be on the lookout for its appearance.

The Meal Snout Moth (*Pyralis farinalis,* Linn).

This is a larger and in many respects more conspicuous species than the ones already described. The writer's attention was attracted to this insect in March, 1909, by finding hundreds of the worms and pupæ in grain bins in one of the Experiment Station buildings. These bins had been in use for a number of years, and it seems that they have not often been entirely emptied, and it is just that condition,

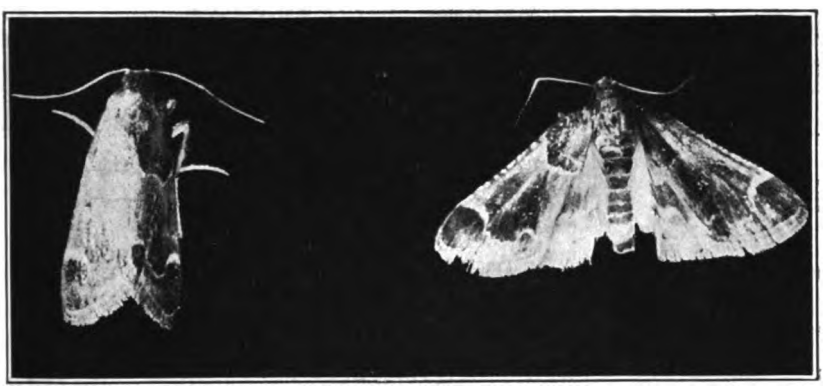

Fig. 12.—The Meal Snout Moth, enlarged two and one-fourth times.

where the bottom of grain bins are never reached, that induces the rapid increase of all kinds of meal worms. The infestation thus found furnished good material for a fumigation experiment, which will be mentioned, and for securing specimens in all stages.

The parent moths are illustrated in Fig. 12 nearly two and one-half times natural size. They measured across the expanded wings from seven-eighths to one and one-eighth inches, and are considerably larger than described by most writers. The females are always larger than the males. The coloring is light or dark brown with reddish reflections, and the wings are crossed by wavy white lines. The moths are nocturnal in their habits and fly quickly when disturbed.

The caterpillars are rather slender and average to measure one inch in length; the head is shiny brown; the first thoracic segment and the anal segments are distinctly orange-yellow in color. In Fig. 13, *a,* is shown its general appearance. Its feeding habits are somewhat like

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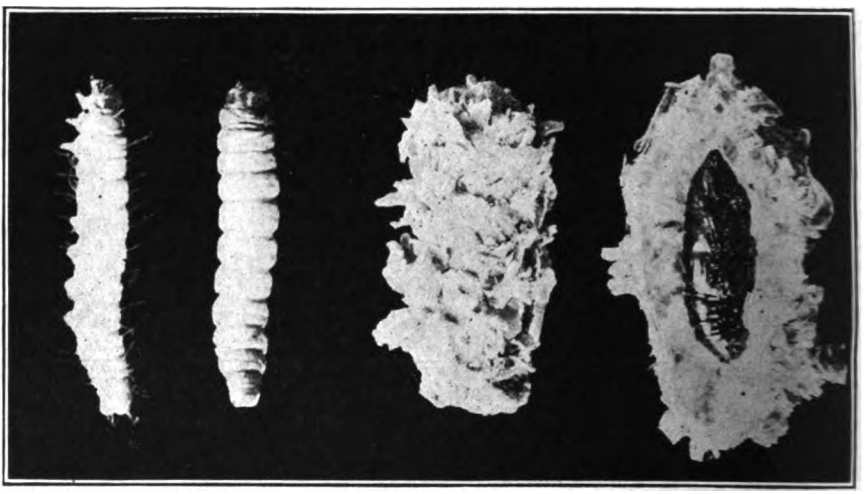
the preceding species, a delicate silken tube being spun as it feeds. The feeding tube (Fig. 14) taken from a bin of bran, and showing the



a *a* *b* *c*

FIG. 13.—The Meal Snout Moth; *a*, larvæ; *b*, cocoon; *c*, pupa in an opened cocoon—all two and one-fourth times natural size.

adhering particles, is constructed out of sticky, silken threads which are always covered with whatever food the worms are working in, whether it be meal, bran, whole wheat or other grain.

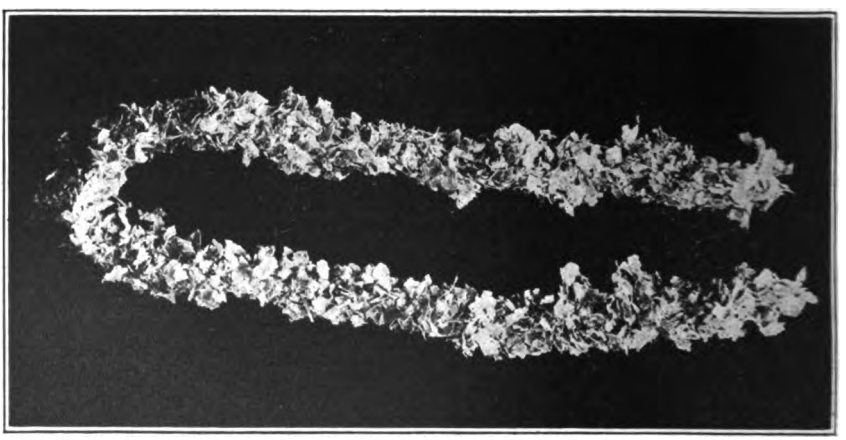


FIG. 14.—Feeding Tube made in bran by the larva of the Meal Snout Moth—slightly reduced.

The pupa stage is assumed in a tough silken cocoon covered with particles of food, as illustrated at Fig. 13, *b*, an open cocoon being

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shown at *c*. The pupa is light reddish-brown and of the form illustrated. Fig. 15 shows a small section of a bran bin covered with meal-worm cocoons, which were equally numerous on all sides.

Concerning the life-history, this species passes the cold months in the larval stage, and at West Raleigh the first moths emerged this year on April 20. Three or four generations annually are credited to this insect.

As a grain pest the meal snout moth is not of great importance. Among its various foods may be mentioned hay, straw, seeds, dried plants, all grains and the products made therefrom, and masses of

FIG. 15.—Showing cocoons of the Meal Snout Moth on the side of a grain bin in which bran was kept.

refuse vegetable matter, such as potatoes. Evidently this insect flourishes best in moist surroundings and is not liable to thrive in material stored in a dry, clean place.

As remedial measures the destruction of infested material and cleaning-out of places where the worms are discovered are by far the best. Fumigation with carbon bisulphide might be effective against the caterpillars in a perfectly tight box or bin, but it is doubtful if the pupa in their cocoons can be killed by any ordinary strength. In the bran bin in which the worms were discovered (see Fig. 15), as already mentioned, carbon bisulphide was used this year at the rate

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of five, ten, fifteen and twenty pounds, respectively, per thousand cubic feet, on April 7, 10, 14, and 15, and after the fourth treatment some of the pupæ were alive and have since transformed to moths. This bin was apparently air-tight except for a crack on the hinged edge of the cover. The details of the experiment need not be discussed here, except to explain that the first and second treatments killed only a small per cent of worms, the third killed nearly all, and the fourth would have been considered a perfect treatment had not a few moths issued later.

PARASITES AND PREDACEOUS ENEMIES.

Nature provides in the form of parasites a means for preventing the unlimited increase of nearly all injurious insects. Even the larval stages of insects in grain are killed frequently by these beneficial parasites, which are small black flies in the adult stage. Two or three species of chalcis flies have been bred from the larvæ of corn weevils and the angoumois grain moth. The other grain moths and meal worms are known to have parasitic enemies whose work in the aggregate is a considerable help toward controlling grain insects. It is not uncommon to find larvæ and pupæ of the angoumois grain moth that have been killed by parasites. Farmers can easily verify these statements by enclosing some weevil-infested grain in a glass jar and observe the minute black flies that emerge.

Among the predaceous enemies may be mentioned mites, spiders, insects of nocturnal habits, birds and bats.

The mites are diminutive, white, spider-like animals, that prey on many species of grain insects. Spiders occurring in the granaries and mills spin webs that entrap many of the grain moths, while bats hover around the grain bins and barns for the purpose of feeding on the moths. The cadelle, already mentioned, feeds on other grain insects, and probably does considerable good in this respect, but its presence is not desirable, as it also does much injury.

GENERAL CONTROL MEASURES.

These may be either preventive or remedial, or a combination of both, as it might properly be termed, when such measures are taken as tend to kill the adult parent forms, which, in many cases, do no damage aside from laying eggs for another generation. Under the head of preventive measures, several things may be mentioned, but no one alone will solve the problem, and the following discussion is given mainly as a suggestion based on the known habits of these insects. Fumigation with carbon bisulphide has in the past been the chief remedy, and is yet to a certain extent, but the reader is requested to note the results of recent experiments that show how difficult it is to confine the poisonous fumes in ordinary granaries long enough to kill

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the various insects that may be present. The old adage "an ounce of prevention is worth a pound of cure" is just as applicable in this connection as it is in troubles of other nature.

PREVENTIVE MEASURES.

Grain first becomes infested through one of two sources: (1) the insects may attack the ripening grain in the field, and (2) the insect may live continuously in barns and granaries ready to commence work in the newly harvested crop. The second source of infestation is more easily prevented than the first.

Field Infestation.—Some species like the rice weevil, angoumois grain moth, saw-tooth grain beetle and a few other small grain beetles are usually found in ripening grain, particularly corn. As a general rule, grain is partially matured, or at least nearly grown, before it is attacked by insects, which of course come from the places in which the grain is stored during the winter. As it cannot be hoped to kill all the insects in stored grains and thus prevent their going to the fields, an effort must be made to prevent them from getting back again in the new grain. Small cereals like wheat and rye should be threshed as soon as dry enough, as that process will kill many of the adult insects and dislodge the eggs. The adult angoumois grain moth is easily crushed and the threshing and handling of the grain destroys many of them. After it is threshed the grain should be stored in tight bins or in sacks, the latter being preferable, because the moths that mature will die without escaping. Whenever the grain, if infested, can be fumigated in practically air-tight boxes or receptacles, carbon bisulphide should be used when the grain is first housed. The practice of storing grain in large bulk is to be commended, as a protection from weevils or grain moths, for then only the surface layers are exposed. This is in direct accord with the recommendation that grain should not be cut and stacked in the field for several months. Such practice tends to allow the insects to infest all the grain more readily than if the same were stored in a large bulk.

Concerning corn particularly, the tight husk offers much protection, and in the field the angoumois grain moth or rice weevil would be excluded almost completely from ears with a husk fitting tightly over the end, were it not for the corn ear-worm, which frequently makes entrance and exit holes, that furnish easy entrance for the grain moths or beetles. However, the presence of the ear-worm is an argument in favor of housing the grain as early as practicable. The longer it is left in the field the greater will be the number of ears infested. Of course, if the farmer does not see that the barns and granaries are free from insects when the grain is stored, the extent of the field infestation is of less importance.

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Cleanliness.—The ideal place to store grain is in a special building separated from the barns, but when grain must be stored in the latter place all old infested grain should be used before the new crop is housed, and precautions should be taken to guard against leaving heaps of waste corn, or other material in which the grain insects may be feeding. The writer has known many farmers to place new corn on top of a few bushels of old corn literally being devoured by the weevils and other insects. Farmers will also often boast that their bins or cribs are never emptied. This practice cannot be too strongly condemned.

Storing Corn in the Husk.—It has often been observed that unhusked corn is less liable to weevil injury, and this is true with varie-

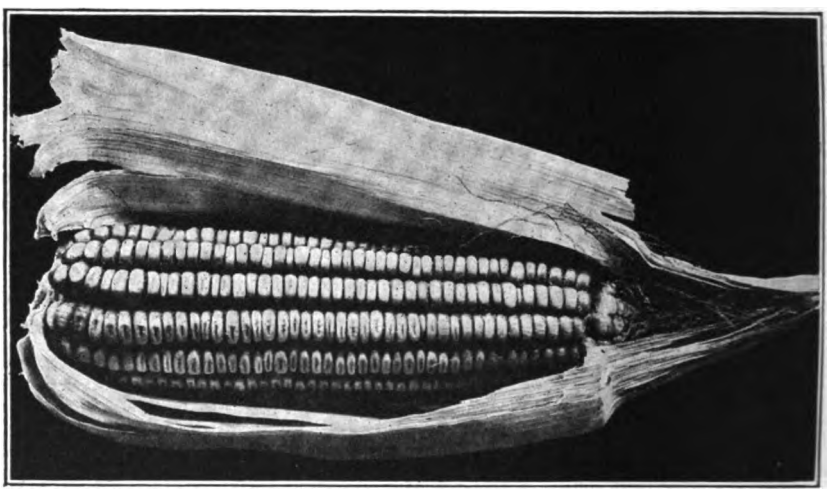

FIG. 16.—Two-year-old Corn showing protection from weevils afforded by a tight-fitting husk—about one-half natural size.

ties that have a tight-fitting husk, when not too badly injured by the ear-worm. In Fig. 16 is shown an ear of corn two years old which was taken from the same lot as the one shown in Fig. 3. It is seen from this cut how the tightly fitting husk acted as a protection. In the same lot, however, the ears on which the husk was loose were all badly injured. When it is considered that corn is nearly always first infested in the field, the value of storing unhusked corn seems somewhat doubtful.

Moth Traps.—All the grain moths are nocturnal in habits and may be attracted to lights. By placing in the corn cribs wide shallow pans containing a little kerosene, with a lantern suspended just above or set in the middle, hundreds of moths may be trapped. They will fly to the light and fall into the pan, and even if they escape again the

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kerosene will kill them. These traps may be used in the spring when the angoumois grain moth commences to emerge, or at any other time when they are abundant.

Repellents.—Various substances have been tried for sprinkling over grain in storage to repel the parent insects, but few are of practical value. Salt, air-slaked lime or powdered sulphur are said to be employed with some success. Naphthalene flakes act as a powerful repellent, but its use is objectionable, and the same is more or less true of the other substances named.

FUMIGATION TREATMENT.

The destruction of insects in stored grains or cereal products, by poisonous fumes, has been recommended by so many writers that many people have come to the conclusion that the treatment must be perfectly reliable; but experience would teach otherwise. Carbon bisulphide is the chief dependence, but other substances, such as benzine, naphtha, carbon tetrachloride, burning sulphur fumes and hydrocyanic acid gas, have been suggested. The last named is a deadly poison, and if used for fumigating in a perfectly air-tight space would be certain death to all grain insects. It is too dangerous, however, to be recommended for general use.

Sulphur Fumes.—The fumes of burning sulphur, chemically known as sulphur dioxide, have long been known as a powerful fumigant and disinfectant, and have been used successfully for destroying rats and other animals. For several years it has been recognized that sulphur fumes would kill insects. During the past fifteen months the writer has made many experiments to see if this knowledge could not be made use of in killing grain pests. The results proved conclusively that sulphur fumes will kill grain insects, not only the adult forms, but the larvæ and pupæ of the rice weevil and angoumois grain moth as well; but the germinating power of the grain so treated is destroyed or much weakened. It was found that the fumes produced by burning two and one-half pounds of sulphur either in a moist or dry atmosphere of one thousand cubic feet space, for twenty hours, would kill all exposed adult insects and practically all the young stages in the grain, but that this also destroyed its germinating power. In making these experiments the sulphur was placed in a metal dish, one side of the pile wet with alcohol, which was sufficient to start the sulphur burning by simply applying a match.

While this treatment cannot be recommended for general fumigation, there is no doubt of its being the easiest and cheapest method of fumigating corn cribs, granaries and similar places whenever they are being cleaned out and freed of insects in preparation for the reception of more grain. The amount stated above will kill all insects

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if the space is made practically air-tight, but if the fumes escape through cracks the amount necessary for successful fumigation cannot be estimated, and the same statement would be true of any poisonous gas.

Carbon Bisulphide Treatment.—Carbon bisulphide is a heavy, clear, foul-smelling liquid, which evaporates rapidly when exposed in shallow dishes. The vapor is a deadly poison when confined in sufficient quantity, and has been extensively used for killing all kinds of insects in stored grain, cereal products, or other material. The amount required is claimed by excellent authorities to be only one pound in 1,000 cubic feet of space, provided there is no escape of the poisonous vapor for about twenty-four hours. This means ideal fumigating conditions, which cannot be secured under ordinary circumstances. The question therefore becomes, what amount of carbon bisulphide must be used to overcome the loss due to leakage? The writer has recently conducted numerous experiments, all of them showing that the diffusibility of carbon bisulphide fumes is greater than generally supposed, and that fumigation of corn, for instance, in a well made, apparently tight grain bin, may not result in killing weevils unless twenty or more times the usually recommended amount be used.

The vapor of carbon bisulphide is 2.64 times heavier than air, so that it settles rapidly if exposed on the top of grain or whatever is being fumigated. This fact has led many people to suppose that it can be used successfully in any space with air-tight sides and bottom, provided the top is covered to exclude currents of air, and that under these conditions the heavy vapor would not escape. It does, however, diffuse in the same manner as other gases, although not as rapidly as those of less specific gravity, and recent experiments have shown that if there is any chance of leakage from the top, the expected results will not be obtained. Where will we find a farmer's grain box, corn crib, or storeroom that can be made air-tight without prohibitive trouble and expense? Not in North Carolina or any other farming district!

One writer has made the statement that, "one pound of carbon bisulphide poured over one hundred bushels of corn will kill all the insects even in open cribs," and farmers are constantly being advised to fumigate with two or three pounds to one thousand cubic feet of space, in fairly tight rooms.

RESULTS OF EXPERIMENTS.

The adult grain moths are killed by the vapor from a small quantity of carbon bisulphide, but the grain beetles require a much greater strength, and it is even more difficult to kill the young stages, larva and pupa, of the rice weevil and angoumois grain moth, in their bur-

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rows. The writer has made numerous experiments with grain insects in all stages, using a practically air-tight fumigating room, one having a padded refrigerator style door and the inside walls covered with asbestos. In this it was found that three pounds of carbon bisulphide to one thousand cubic feet, fumigating for twenty-one hours, killed practically all adult insects, but not over seventy per cent of the larvæ and pupæ of the angoumois grain moth or rice weevil.

For an experiment corresponding to farm conditions a grain box of about forty cubic feet capacity was used; the sides were made of matched boards and the floor of concrete; the top edges were covered with sacks and the hinged cover nailed down on three sides when fumigation commenced. The bin was about one-third full of bran. Carbon bisulphide was used by exposing it in shallow dishes near the cover, tests being made with ten, fifteen and twenty pounds, respectively, to one thousand cubic feet space, for twenty-four to twenty-six hours. Larvæ, pupæ and adults of both rice weevil and angoumois grain moth and adult cadelle beetles were used in each test. It was found that the greatest strength used did not kill all the insects twelve inches below the cover, and the average result was not equal to that obtained by using three pounds for twenty-one hours in the tight fumigating room, already described. In view of these results, the writer is forced to conclude that carbon bisulphide, at any reasonable strength, cannot be successfully used for fumigating grain in ordinary corn cribs, grain boxes or storerooms.

Small quantities of infested grain can be fumigated in absolutely tight boxes or barrels by using about one ounce to three bushels. The top must be rendered air-tight, not simply covered with blankets or canvas. Fumigation should continue for about twenty-four hours.

Caution.—The vapor of carbon bisulphide is inflammable and explosive, hence those who use it must be certain that no lighted lanterns or fire of any kind be brought around where fumigation is being made. Any supply on hand should be kept securely sealed and placed in a ventilated room. As a further precaution it may be marked "Inflammable."

The purchase price is about thirty to thirty-five cents a pound from retail druggists, but as low as eight or ten cents per pound when ordered from the manufacturers, who make a commercial grade especially for fumigating purposes.

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BULLETIN 204 JUNE, 1909

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

WEST RALEIGH

SOME FACTORS INVOLVED IN SUCCESSFUL CORN GROWING.

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N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,

UNDER THE CONTROL OF THE

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The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
West Raleigh, N. C.

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SOME FACTORS INVOLVED IN SUCCESSFUL CORN GROWING.

By C. B. Williams, Director.

Information concerning proper methods of selecting seed of different farm crops is of vital importance to farmers, for the same thought and effort put into few other operations of the farm bring such good financial returns. A few hours spent in intelligent field selection of seed of corn each year may be expected to lead to an annual increase of two to five bushels more per acre from these seed than from those selected by the ordinary methods.

In consideration of the promise in this neglected field of work in North Carolina, and that over forty-seven per cent of all land cultivated in the State is devoted to corn, with the use of something like 450,000 bushels of seed corn and a small average annual yield of 13.4 bushels of shelled corn per acre, the Experiment Station six years ago began experiments to determine the relative value of different varieties of corn as producers of shelled corn per acre. During the time covered by these trials many cases in which one or more varieties have produced from five to ten bushels more per acre than other varieties have been observed. Conjointly with these experiments, seed selection work has been carried on with the hope of ascertaining much practical information, the application of which by farmers would lead to materially increased yields of this cereal.

It should be borne in mind, in the beginning, that the underlying principles of plant and animal improvement are almost identical, and that similar methods to those which have been adopted in the improvement of the various breeds of live stock must be followed by those who wish to grow plants of increasing productiveness. It must also be remembered that as intelligent feeding and good care stand to animal breeding, so do proper fertilization and thorough cultivation of the soil stand to plant breeding or improvement; for if proper food and care are not furnished both plants and animals, improved breeding will not only be impossible, but retrogression inevitable. With the same thought and care, results are secured much quicker with plants than with animals, as a completed growth is obtained in one year with most plants, while with animals it requires several years to secure complete knowledge of what one has obtained by a certain cross.

STARTING WORK.

The method that is being followed by the Station is to conduct comparative tests of all the known varieties of promise grown and offered for sale in this and nearby States through a sufficient number of years to secure average weather conditions.

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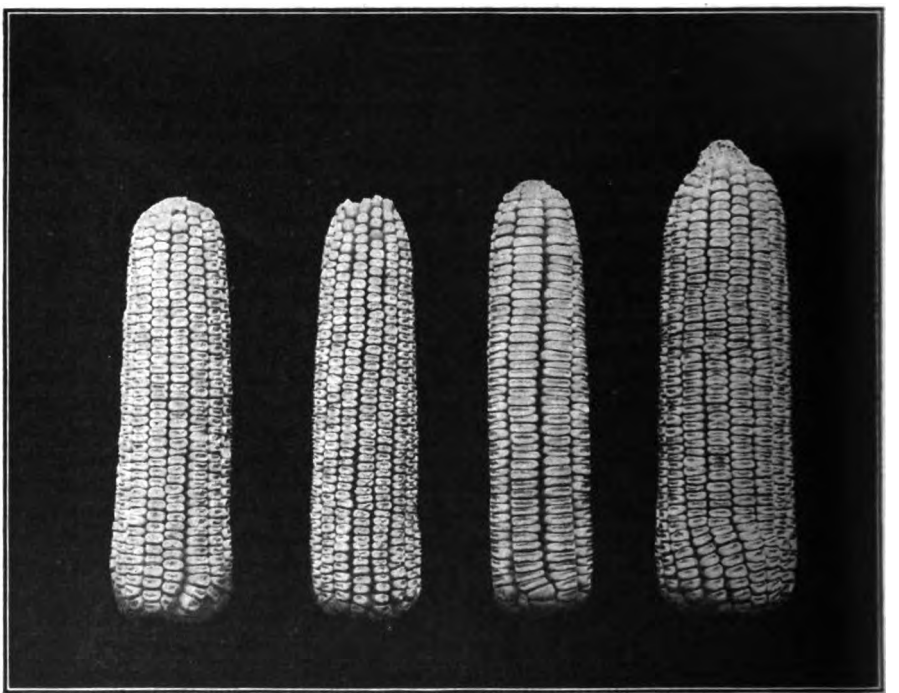
With the variety or varieties demonstrated by these tests to be the most prolific of shelled corn per acre, field seed selection for further improvement was begun and systematically continued; having uppermost in mind, in selecting seed, total yield per acre. By this means it has been observed that the yielding power of a variety may be greatly increased within a few years.



(1) (2) (3) (4)

FIG. 1.—Type Ears of Varieties: (1) Sharber's; (2) Jackson's Whitecap Prolific; (3) Hickory [illegible] (Virginia); and (4) McAuley's White Dent.

TESTING VARIETIES.

The testing of varieties of all agricultural crops is of the most fundamental importance, as is evidenced by the differences in yield of different varieties grown side by side in the same field, on the same type of soil, with identical cultivation and fertilization; these differences being due largely to the inherent qualities of the seed of the individual varieties which have been transmitted from parent to progeny.

During the past six years on the Station farm something over seventy-five varieties of corn have been studied in comparative field tests. The number of varieties in the different tests have ranged all the way from nineteen in 1903 to sixty-eight in 1908. The different tests of varieties were conducted as nearly under the same conditions of soil, fertilization

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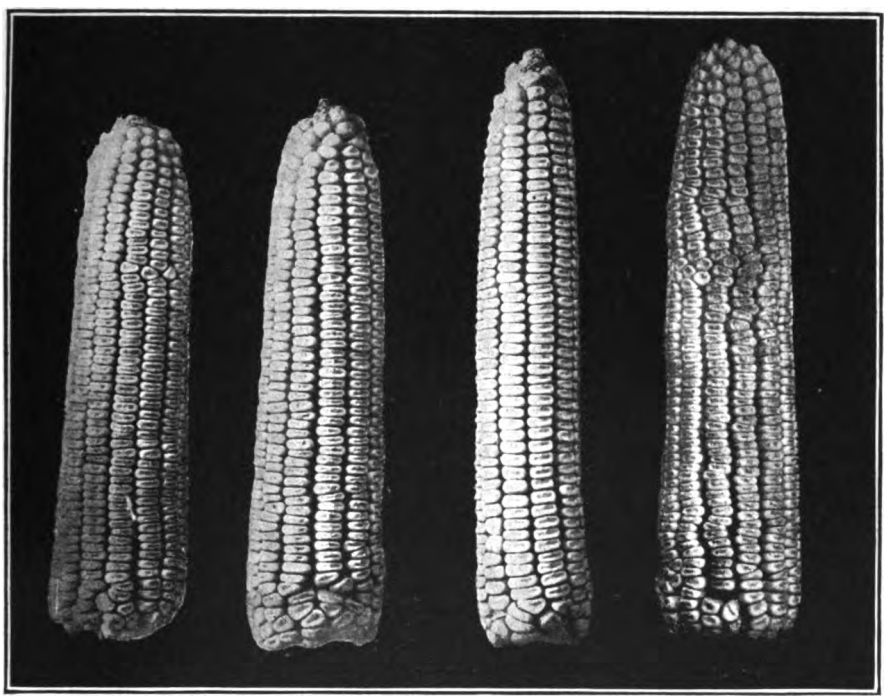
and cultivation as it was possible to provide. To eliminate inequalities in the character of the land, if any, the varieties were planted each in separate rows, arranged consecutively, and this plan was repeated from three to five times, varying with the length of the rows, in order to give the desired acreage to each variety. By taking these precautions the results obtained should be reliable and highly valuable.

WHAT IS A VARIETY?

A variety is supposed to represent a class of plants with one or more distinguishing characteristics, but with a cereal like corn, which mixes



(5) (6) (7) (8)

FIG. 2.—Type Ears of Varieties: (5) Cocke's Prolific; (6) Weekley's Improved; (7) Shellem's Prolific; and (8) Wilson's Success.

so freely that variety does not mean much unless proper precautions have been exercised in its growth.

Take some variety of corn—say Cocke's Prolific—that has been bred carefully and intelligently for about an hundred years for high yield of shelled corn per stalk, and grow it continuously in or adjacent to a field of inferior corn, and in a very short time, especially if proper seed selection is not practiced, it will give much smaller yields when grown under the same conditions than the original pure-bred corn; this being

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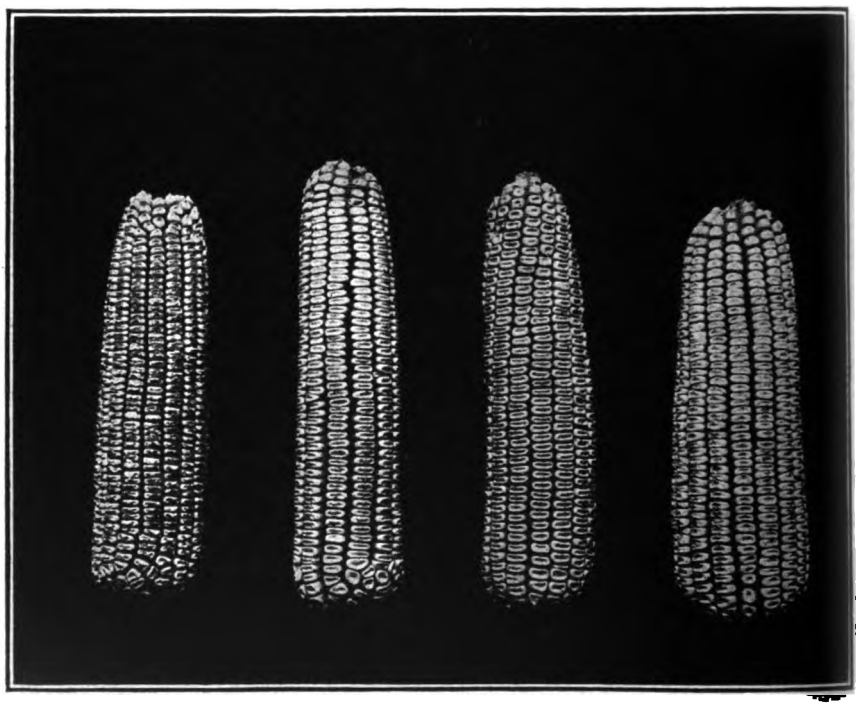
due to the fact that you no longer have pure Cocke's Prolific, but a mixture of scrub and Cocke's Prolific corn. This fact emphasizes the importance of securing seed from reliable parties.

EARLY MATURING VARIETIES.

Leaming Yellow, Iowa Silvermine, Riley's Favorite, Reid's Yellow Dent, Boone County White, Boone County Special and Pool's are seven of the earliest varieties in maturing that have thus far been studied at the Station farm. These, with the exception of Pool's, which is from the upper Piedmont section of this State, were all originated and brought



(9) (10) (11) (12)

FIG. 3.—Type Ears of Varieties: (9) Dodson's Prolific Shoepeg; (10) Culpepper's Extra Prolific; (11) Biggs' Seven-ear; and (12) Brake's.

for the tests from the Western Central States, where they have been accustomed to a comparatively short growing season, which accounts largely for their inherent tendency to early maturity when grown under North Carolina conditions. Earliness, however, is not considered an important requisite with corn for this climate, except, possibly, where it is grown in the mountainous section of the State, or where corn, of necessity, has to be planted late, after the maturity of some truck crop, like Irish potatoes. Under these circumstances it may be well to use one of the varieties mentioned above, especially if experience has taught

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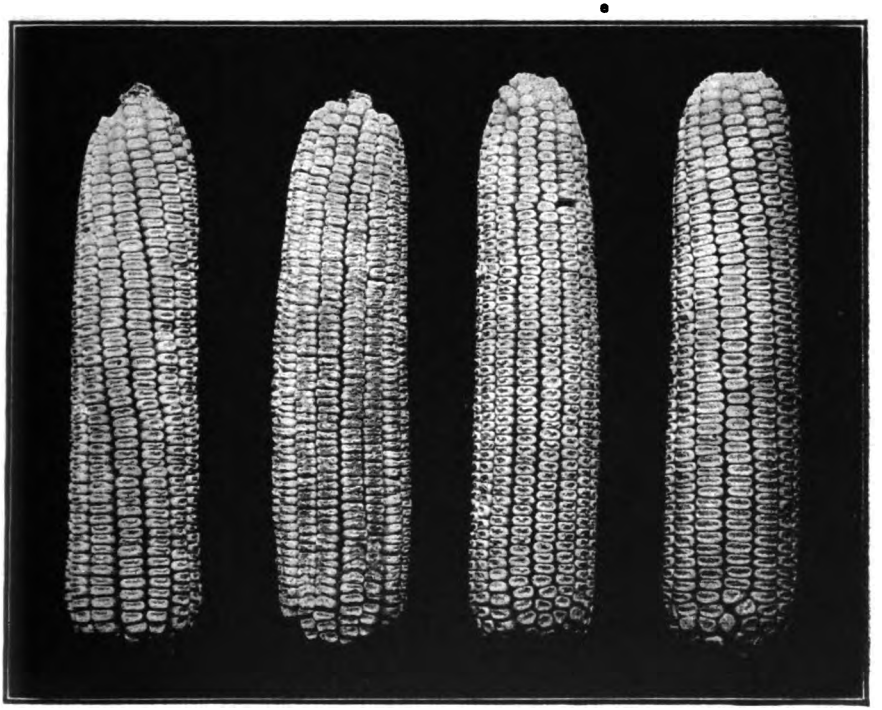
the farmer that local varieties do not thoroughly mature before frost. Under North Carolina conditions of climate and soil these varieties will usually mature from planting in one hundred to one hundred and ten days.

MEDIUM MATURING VARIETIES.

Hickory King, Biggs' Seven-ear, Cocke's Prolific, Wyatt's Improved Yellow, MacMackin's Gourdseed, Peele's Prolific and Farmers' Favorite mature at a medium date in the fall, and some of these are the best yielders grown in the State. All these will usually mature on the different types of soil of North Carolina east of the mountains in one hundred and ten to one hundred and twenty days.



(13) (14) (15) (16)

FIG. 4.—Type Ears of Varieties: (13) Williams'; (14) Krimminger's Improved; (15) Osborne; and (16) Farmers' Favorite.

LATE MATURING VARIETIES.

It has been found that Gourdseed, Hastings' Prolific, Mosby's Prolific, Brake's, Harris' Improved, Williams', Osborne, Horsetooth, Holt's Strawberry, Sanders' Improved, Fredonia's Pride, Latham's Improved, Weekley's Improved, Marlboro Prolific, Henry Grady, Bagley's Improved, Cleckler's Improved, Cooper's Improved, Jarvis' Improved, Fry's Improved and Sharber's, in about the order named, are some of the latest maturing varieties tested during the past four or five years. These

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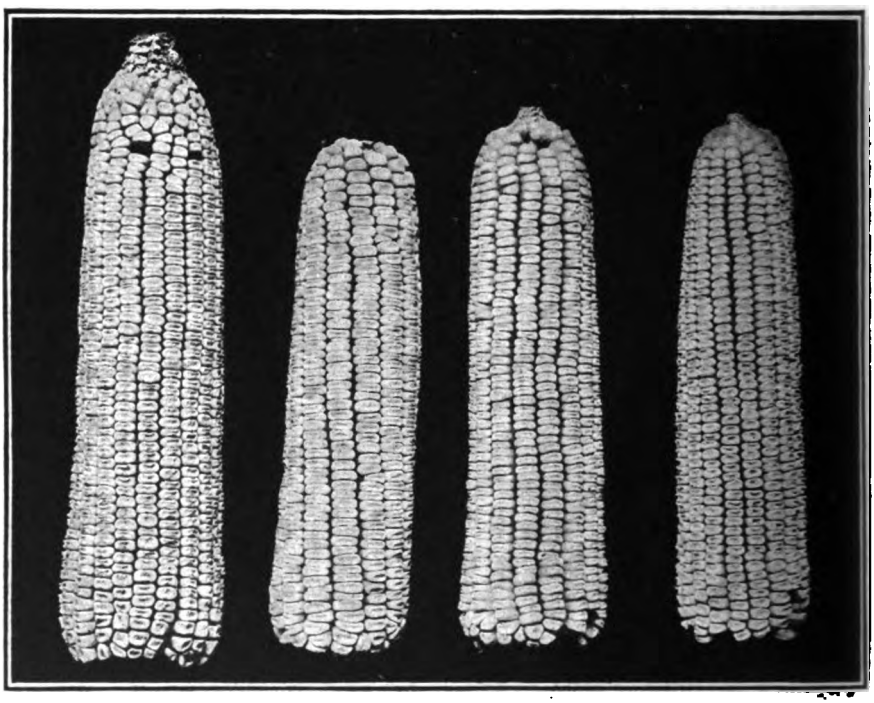
varieties are vigorous growers and generally produce large, tall stalks, and many of them have evidently been bred to produce one large ear per stalk. In this climate they will mature usually in one hundred and twenty to one hundred and thirty-five days.

VARIETIES ADAPTED TO EASTERN OR COASTAL SECTION.

For the sandy and fine sandy loam soils of the eastern and southeastern portions of the State, Cocke's Prolific, Biggs' Seven-ear, Weekley's Improved, Sanders' Improved, Hickory King, Holt's Strawberry,



(17) (18) (19) (20)

FIG. 5.—Type Ears of Varieties: (17) Harris' Improved; (18) Whelchel's Dent; (19) Cooper's Improved; and (20) Peele's Prolific.

American Queen, Bagley's Improved, Brake's, Cooper's Improved, Jarvis' Improved and Latham's Improved are recommended as good varieties for planting, if pure seed are secured. Of these varieties Biggs' Seven-ear, Weekley's Improved, Cocke's Prolific and Sanders' Improved, in the order named, are the most prolific. Bagley's Improved, Jarvis' Improved and Brake's possess the largest ears.

VARIETIES ADAPTED TO PIEDMONT SECTION.

It has been found from a testing of a large number of varieties during the past six years that Biggs' Seven-ear, Sanders' Improved, Weekley's

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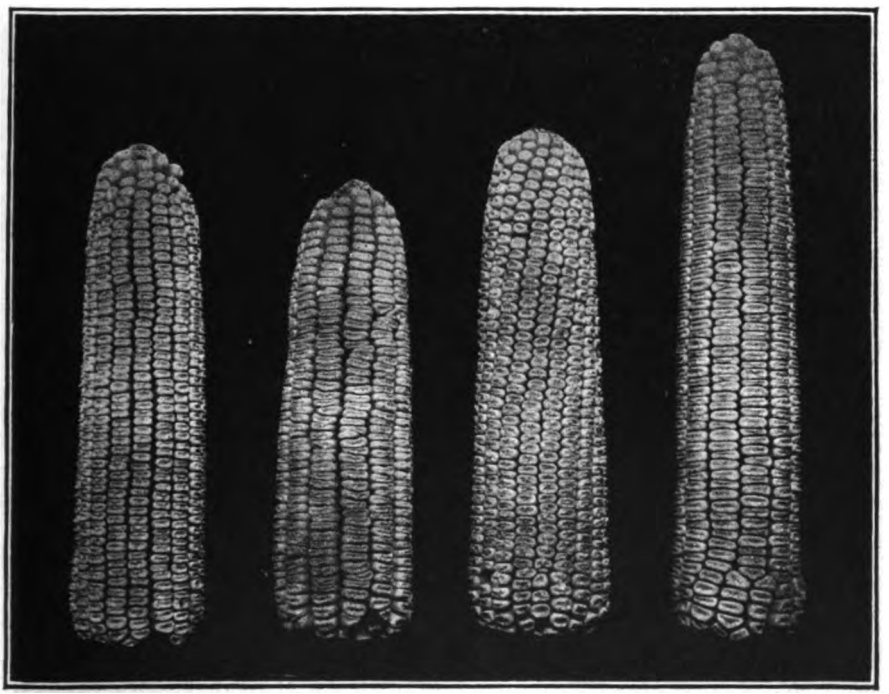
Improved, Cocke's Prolific, Marlboro Prolific, American Queen, Brake's, Holt's Strawberry, Southern Beauty, Bagley's Improved, Farmers' Favorite, Boone County White, Hickory King and Horsetooth are the largest yielders of shelled corn per acre of all the varieties thus far tested for elevations below about 2,500 feet. These are all white-eared varieties, with the exception of Holt's Strawberry, and are medium to medium late in maturity. It will be observed that many of these are the leading varieties recommended for the eastern portion of the State, but the order as yielders of the varieties is somewhat changed.



(21) (22) (23) (24)

FIG. 6.—Type Ears of Varieties: (21) Goodman's Prolific; (22) Columbian Beauty; (23) Jones' White; and (24) Wright's Improved.

VARIETIES ADAPTED TO MOUNTAIN SECTION.

For those portions of the transmontane region elevated more than 2,500 feet above sea level, and which are devoted to the growth of corn, Boone County White, Leaming Yellow, MacMackin's Gourdseed, Riley's Favorite, Iowa Silvermine and Reid's Yellow Dent are suggested as varieties of dent corn which may be grown to good advantage. For those mountain plateaus elevated about 2,800 to 3,000 feet and which have quite cool nights it will be found that the flint types of corn will do well.

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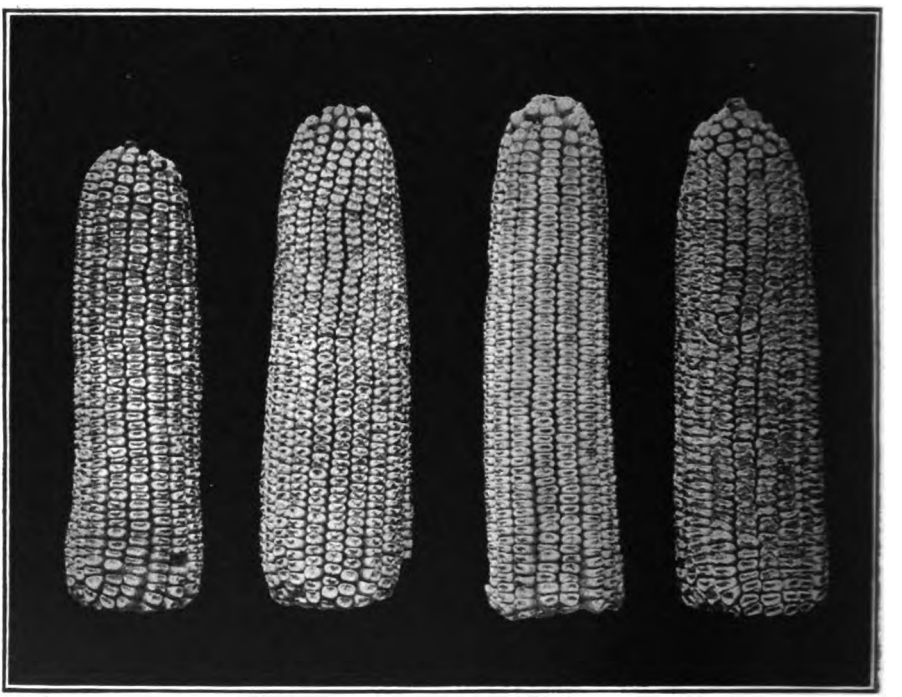
NORTHERN VERSUS SOUTHERN VARIETIES.

As pointed out elsewhere in this Bulletin, the best of the northern-grown varieties of corn have not proven to be the heaviest yielders for the cismontane portions of North Carolina. Neither have varieties coming from the far South yielded as well as the best of those seed which have come from nearer home. In the Station tests, Biggs' Seven-ear, a North Carolina originated variety, has as an average of three years' results, produced 2.4 bushels more of shelled corn per acre than has Reid's Yellow Dent, originated in Illinois, and 4.2 bushels more than



(25) (26) (27) (28)

FIG. 7.—Type Ears of Varieties: (25) Cleveland's Pure White; (26) Fredonia's Pride; (27) Thomas' Improved; and (28) Horsetooth.

Mosby's Prolific, bred in southern Mississippi. Southern corn generally produces a larger and taller stalk, and bears the ears at a greater height, than do those varieties brought from higher elevations and latitudes. The northern varieties, on the other hand, produce a larger ear in proportion to the size of the stalk than do Southern varieties, as is shown by the results contained in Table I. It will also be noted from these data that the percentage the ear is of total plant of both Southern and Northern varieties increases, with only four exceptions, as the yields are made better. The average percentage of ear of total dry plant, as an average of four years' tests, is, for the five Southern varieties, 40.9 per

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TABLE I.—SHOWING FIVE YEARS' YIELD OF GRAIN AND EAR PERCENTAGE OF TOTAL PLANT OF SOUTHERN AND NORTHWESTERN VARIETIES OF CORN WHEN ALL WERE GROWN UNDER THE SAME CONDITIONS.

Varieties.	Source of Seed.	1903.		1904.		1905.		1906.		1907.		Average of Four Years.	
		Yield of Grain per Acre—Bushels.	Ears of Total Plant—Per Cent.	Yield of Grain per Acre—Bushels.	Ears of Total Plant—Per Cent.	Yield of Grain per Acre—Bushels.	Ears of Total Plant—Per Acre.	Yield of Grain per Acre—Bushels.	Ears of Total Plant—Per Cent.	Yield of Grain per Acre—Bushels.	Ears of Total Plant—Per Cent.	Yield of Grain per Acre—Bushels.[1]	Ears of Total Plant—Per Cent.
Southern Varieties.													
Cocke's Prolific	North Carolina	20.2	41.1	24.8	42.9	31.9	56.4	24.4	------	15.9	30.0	23.2	42.6
Weekley's Improved	North Carolina	19.8	44.0	22.1	40.8	28.1	48.4	20.8	------	23.7	36.6	23.4	42.5
Sanders' Improved	Georgia	23.2	42.2	25.1	43.2	31.7	49.0	21.2	------	20.2	33.8	25.1	42.1
Cocke's Prolific	Tennessee	20.1	39.4	20.6	43.4	25.9	43.3	22.3	------	18.4	31.7	21.3	39.5
Mosby's Prolific	Mississippi	19.5	38.1	21.5	39.8	24.7	42.8	20.5	------	14.6	31.3	20.1	38.0
Averages		20.6	41.0	22.8	42.0	28.5	48.0	21.8	------	18.6	32.7	22.6	40.9
Northwestern Varieties.													
Iowa Silvermine	Illinois	15.7	36.9	20.7	48.6	26.9	58.3	21.4	------	17.6	45.3	20.2	47.3
Leaming Yellow	Ohio	19.4	46.6	23.7	55.0	29.6	63.6	20.5	------	19.4	48.9	23.0	53.5
Reid's Yellow Dent	Illinois	18.2	45.4	25.1	51.9	28.3	57.1	21.6	------	20.3	42.5	23.0	49.2
Riley's Favorite	Indiana	15.1	44.0	23.7	50.7	27.3	57.9	20.2	------	20.1	44.1	21.6	49.2
Boone County White	Indiana	14.4	37.9	21.8	47.4	29.2	54.4	22.7	------	21.0	44.8	21.6	46.1
Averages		16.6	42.2	23.0	50.7	28.3	58.3	21.3	------	19.7	45.1	21.9	49.1

[1]The data in this column do not embrace the results secured in 1906.

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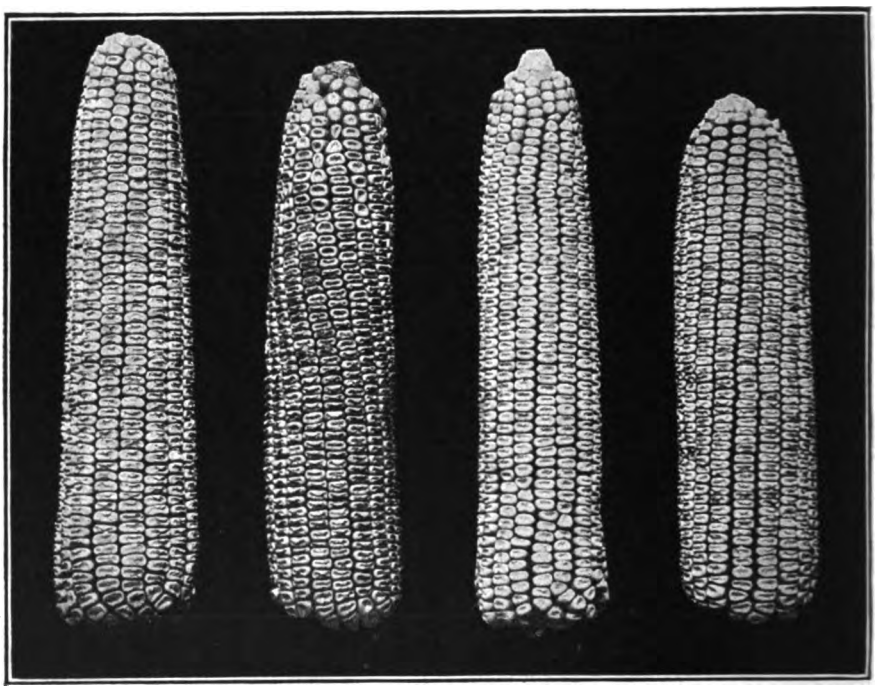
cent, and for the five Northern varieties, 49.1 per cent. With the average yield of the Northern corns, being 0.7 bushels less per acre, they have produced 8.2 per cent more ear to total plant than did the varieties from the South.

FACTORS AFFECTING PERIOD OF MATURITY.

With corn as with other plants, the number of days required for the growth of the plants from the sprouting of the seed to full maturity is governed, within narrow limits, by variety, soil, season, elevation, fertilization, date of planting and source of seed. Of the varieties grown in different portions of North Carolina, it usually requires from one hun-



(29) (30) (31) (32)

FIG. 8.—Type Ears of Varieties: (29) Leaming Yellow; (30) Kansas Sunflower; (31) Jones' Yellow Dent; and (32) Hildreth's Yellow Dent.

dred to one hundred and forty days to make a completed growth from planting.

Effect of Variety.—In the study of varieties of corn during the past few years many instances of differences in earliness in maturity of varieties, originated under the same conditions and sometimes by the same grower, have come under the observation of the writer. To some extent the originator or improver of a variety may select seed in such a manner as to have the variety within a few years mature at either an early, medium or late date. Jarvis' Improved, which was originated

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